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An Investigation Of Seriation And Perception In The Structure And Function Of Intellect In The Educable Mentally Retarded

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AN INVESTIGATION OF SERIATION AND PERCEPTION IN THE STRUCTURE AND FUNCTION OF INTELLECT IN THE EDUCABLE MENTALLY RETARDED

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AN INVESTIGATION OF SERIATION AND PERCEPTION IN THE STRUCTURE AND FUNCTION OF INTELLECT IN THE EDUCABLE MENTALLY RETARDED

Abstract of Dissertation

This study is relevant to the potential utility of a developmental approach to the assessment of ability in students designated "Educable Mentally Retarded". Piaget's conceptualization of seriation as an essential component of logical thinking, related to perception, suggested a linkage between dimensions of thinking and imagery, generally treated independently.

Subjects were seventy-four elementary students in EMR classes, tested on a variety of procedures. The major statistical technique was analysis of variance in a 2 x 2 factorial design. Socio-economic level and ethnic group, used as independent variables, measured these effects independently and in interaction with developmental constructs related to school progress: intelligence, perception, and seriation. Academic achievement, age, and sex were also studied as control factors. Data not suitable for this treatment were used in contingency tables, and Chi-square computed, to estimate significance. Correlational analysis provided direct expression of degree of relationship among the factors studied and partial correlation, statistically eliminating effects of a third variable, was also used.

There were close relationships between seriation and perception, seriation and arithmetic, and perception and arithmetic. Overlap of function was substantiated. This was confirmed by analysis of variance studies in which the most significant effects on seriation were associated with perception and arithmetic achievement. IQ and age were also significant factors. The F-test failed to support statistical significance for effects of ethnic group, social class, or sex on seriating ability. There were consistent (but not statistically significant) differences in group mean scores: girls did better than boys; lower class did better than middle class; and, the ethnic minorities were higher than the whites. Distribution of scores on both Visual-Motor Integration Test and Conception of Space differentiated ethnic groups, as tested by Chi-square. IQ was more significantly related to perceptual development than was age. Seriation was more closely related to skill achievement than was IQ.

Conclusions:

1. Markedly delayed development in both perceptual and seriating ability is associated with impairment in intellectual functioning.

2. There is mutual interdependence between perception and intelligence and, in this population, IQ is more closely associated with development of seriation and perception than maturation or age alone.

3. Conceptualization of seriation as a structure in logical thinking reflects empirically verifiable changes in the mental life of the growing child.

4. Solution of inadequacies and problems in intelligence testing may lie in the extension of testing procedures.

5. Individual assessmen, evaluating development of reasoning in a process oriented approach moves closer to educational demands for effective prescriptive testing.

6. Consistent differences, which favored ethnic minorities and lower socio-economic groups in seriating ability and perceptual development, suggest that remedial procedures for these pupils in special education should be attempted.

Of all the vulgar modes of escaping from the consideration of the effect of the social and moral influences on the human mind, the most vulgar is that of attributing the diversities of conduct and character to inherent natural differences.

John Stuart Mill (1861)

...it is no longer unreasonable to consider that it might be feasible to discover ways to govern the encounters that children have with their environments, especially during the early years of their development, to achieve a substantially higher adult level of intellectual capacity...ours is a technological culture of ever increasing complexity. Its development continually demands an ever larger proportion of the population with intellectual capacity at the higher levels...The fact that it is reasonable to hope to find ways of raising the level of intellectual capacity in a majority of the population makes it a challenge to do the necessary research.

J. McVickers Hunt (1961)

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CHAPTER I

INTRODUCTION

The current debates about desirable practice and curricular modifications necessary to meet the needs of the academically retarded and the slow learners in the schools are waged with particular intensity as related to the placement and labelling of these students in the classes for "Educable Mentally Retarded". There appears to be a need for further clarification in this area. Among the pressing questions arising from the current polemics, the following are heard most frequently:[1]

1. Are there qualitative as well as quantitative differences in mentation between those identified as retarded and the so-called normals?

2. Are there discernible differences among the retarded pupils related to differences in socio-economic level or ethnic background?

3. Are there factors which differentiate among groups of retarded relative to academic achievement?

STATEMENT OF THE PROBLEM

The present study is designed to test the potential utility of a developmental approach to the evaluation and assessment of mental ability in a group of students designated as "Educable Mentally Retarded". The application of an aspect of Piaget's genetic epistemology is proposed to elucidate some of the questions about the learning abilities of these pupils.

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[1] Cf. infra., pp. 13-14, and further elaboration in Chapter II, Review of the Literature.

Piaget has postulated two developmental "operations", classification and seriation, as being fused in the course of child development, making possible the emergence of logical thinking.[2] The process of seriation and its relationship to perception and cognitive development in the Educable Mentally Retarded is the focus of this study.

Statistical methods designed for multivariate, interaction analysis permit non-experimental inquiry of mental growth with particular attention to the possible sources of variance.[3] This investigation is directed toward both (a) substantive problems related to assessment and education of the retarded and (b) theoretical questions about the structure and function of the intellect in this population.

BACKGROUND OF THE STUDY

The problem is multifaceted, dealing with a number of concepts which are ambiguously defined in the literature, fraught with conflict in practice, and capable of varying interpretations in different theoretical systems. These concepts reflect interest and concern on a variety of levels for a heterogeneous group of workers in research and applied work. The problems implicit in the use of these popular, loosely defined terms are described as a prelude to the statement of the significance and purposes of the study.

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[2] Cf. infra., pp. 9-12, and further elaboration in Chapter II, Review of the Literature.

[3] The testing procedures and statistical methods are discussed in Chapter III, Design of the Study.

Mental Retardation

With the wider-spread implementation of compulsory education in the western hemisphere, the problem of the mentally subnormal has received increasing attention from a multidisciplinary group representing education, medicine, psychology, and sociology.[4] In somewhat different terms and measures, each of these disciplines has adopted a descriptive system of classificatory scheme for its work with this population. These constitute quasi-definitions; however, they vary to an extent that precludes agreement on the parameters of the population under consideration.

It is widely acknowledged that mental retardation is neither a precisely defined syndrome nor a diagnostic entity.[5] From an administrative point of view, action taken in regard to mental deviation depends not only on the nature or degree of the individual's shortcomings but on the threshholds of community tolerance for aberration. There is, consequently, a discrepancy in the data reported on the incidence and prevalence of mental retardation.[6] Penrose interprets this discrepancy

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[4] N. R. Ellis (Ed.), Handbook of Mental Deficiency (McGraw Hill Book Co., New York, 1963).

[5] S. B. Sarason and T. Gladwin, Psychological Problems in Mental Deficiency (Harper and Row, New York, 1959, 3rd ed.) p. 412.

[6] N. O'Connor, "The Prevalence of Mental Defect" in A. M. Clarke and D. B. Clarke (Eds.) Mental Deficiency: The Changing Outlook (The Free Press, Glencoe, Ill., 1958) p. 26.

as evidence of the fact that mental defect is largely socially determined.[7] Indeed, the increased incidence of mental retardation which is reported in the age range 9 to 14, when academic pressure is most intense, suggests other questions about the nature of this alleged entity and the relationship between 'intelligence' and academic aptitude. O'Connor summarizes this state of affairs as follows:

> Assessment, therefore, becomes excessively complicated because the criteria are ill-defined, methods more or less comprehensive, and because even individual attitudes or financial considerations or group mores may effect ascertainment, and, as a consequence, the assessment of the prevalence of mental defect.[8]

Intellectual Assessment

The identification and placement of school aged children as 'retarded' for educational purposes has been based largely on psychometric testing. But the era of psychological testing which flourished for the past several decades appears to be reaching a crisis. There is presently a significant protest movement against the use of educational and psychological tests in the schools. One of the foremost authorities on psychological tests, Anastasi, points out that:

> ...psychologists specializing in psychometrics have been devoting more and more of their efforts to refining the techniques of test construction, while losing sight of the behavior they set out to measure. Psychological testing today places too much emphasis on testing and too little on psychology. As a result, outdated interpretations of test performance may remain insulated from the impact of subsequent behavior research

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[7] L. S. Penrose, The Biology of Mental Defect (Sidgwick and Jackson, London, 1954, rev. ed.).

[8] O'Connor, op. cit., p. 23.

> ...The isolation of psychometrics from other relevant areas of psychology is one of the conditions that have led to the prevalent public hostility toward testing.[9]

It seems that the protest movement against psychological testing represents the convergence of two independent streams in current psychological thinking: (a) those who argue that present techniques are culturally biased and (b) those who claim that intelligence is not a unidimensional function and cannot be assessed by global scores.

On the one hand there is the argument that even the best aptitude and ability tests, which may have excellent criterion validity for some purposes, are unlikely to reflect the true capacity for development of underprivileged children.[10] Associated with the categorization and isolation of 'retarded' students is the potential hazard of impaired self-concept and even less motivation and opportunity for remediation. This is one of the arguments cited by current authors in pointing out that the pupils from the ethnic minority groups and lower socio-economic levels who constitute the bulk of the special education classes are thereby multiply disadvantaged.[11] It is demonstrated that ability tests measure factors which are related to academic success and tap dimensions which are molded by the cultural setting.[12] Consequently, the reliability and predictive validity of these tests is disputed. In response to

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[9] A. Anastasi, "Psychology, Psychologists, and Psychological Testing", American Psychologist, 1967, 22, p. 297.

[10] L. M. Dunn, "Special Education for the Retarded: Is much of It Justifiable"? Exceptional Children, 1968, 35, 5-24.

[11] Ibid.

[12] J. A. Fishman, et al., "Guidelines for Testing Minority Group Children", Monograph Supplement Journal of Social Issues, 1964, 20, No. 2, 127-145.

the pressure for solution of such problems, there have been abortive efforts to produce "culture free" or "culture fair" tests.[13, 14]

The Meaning of Intelligence

At the same time, there have been a plethora of reports from investigators who attack the concept of a global evaluation of 'intelligence' and reject the interpretations based on omnibus type tests. It is argued that present intelligence tests are actually based on only a few of many abilities (allegedly independent) which have been inferred from factor analytic studies.[15] There is a substantial case for the use of multidimensional measures to replace the unidimensional IQ concept.[16] However, there are notable spokesmen in defense of the 'unitary', general ability test, critical of the factor analysts. McNemar says that the data is being factored out to inconsequential trivia and "more and more factors signifying less and less are being reported".[17] McNemar concludes that although the thousands of research studies on the diversity of the organism increase the body of knowledge on individual differences, nevertheless:

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[13] K. Eells, et al., Intelligence and Cultural Differences (University of Chicago Press, Chicago, 1951).

[14] A. Anastasi, "Standardized Ability Testing" in P. H. Mussen (Ed.), Handbook of Research Methods in Child Psychology (John Wiley and Sons, New York, 1960) p. 483.

[15] J. P. Guilford, "The Structure of Intellect", Psychological Bulletin, 1956, 53, 267-293

[16] J. P. Guilford, The Nature of Intelligence, (McGraw Hill Book Co., New York, 1967) pp. 46 et seqq.

[17] Q. McNemar, "Lost: Our Intelligence? Why"? American Psychologist, 1964, 19, 871-883.

> ...these studies of individual differences never come to grips with the process or operation by which a given organism achieves an intellectual response. Indeed, it is difficult to see how the available individual difference data can be used even as a starting point for generating a theory as to the process nature of general intelligence or of any other specified ability.[18]

There are many conflicts and doubts expressed about what is being measured in these tests. This suggests that there has been insufficient, if any, heed to the plea of caution in Dearborn's biblical reference which warns of a failure of testing to fulfill its function.[19] He recalls that a speech test was used on one occasion. Those who could not pronounce the word 'shibboleth' correctly were deemed to be Ephraimites, and slain at the passage of the Jordan. The victorious men of Gilead were not concerned over the possibility of diagnostic mistakes because the test was short, easy to administer, and gave a clear-cut answer which did not require further thinking.

Developmental Psychology

Child development was marked as a field of inquiry before the turn of the century, but developmental theory, as such, was articulated in the works of Jean Piaget[20] and Heinz Werner.[21] Werner explains:

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[18] Ibid., p. 881.

[19] W. Dearborn, "The Development of the Intellect", in M. W. O'Shea (Ed.) The Child: His Nature and His Needs (The Children's Foundation, Valparaiso, Indiana, 1924) p. 73.

[20] J. Piaget, The Language and Thought of the Child (Harcourt, Brace, New York, 1926).

[21] H. Werner, Comparative Psychology of Mental Development (International Universities Press, Inc., New York, 1957, rev. ed.).

> The concept of 'developmental psychology' is perfectly clear if this term is understood to mean a science concerned with the development of mental life, and determined by a specific method, i.e., the observation of psychological phenomena from the standpoint of development...There are certain investigators who, when they use the term 'developmental psychology', refer solely to the problem of ontogenesis. The mental development of the individual is, however, but one theme in genetic psychology. Related to the developmental psychology of the individual is the developmental study of larger social unities, a field of interest intimately linked with anthropology and best known by the name of ethnopsychology.[22]

Researchers have recognized the possibilities in the application of the concepts from developmental psychology ('genetic epistemology' in Piaget's terms) to the study of intellectual development and function in the mentally retarded.[23,24,25] Werner himself saw the potentialities for enhancing the understanding of normal development by studying the pathological and did many studies on mental growth in the retarded.[26] All of these efforts, however, were directed to the ontogenetic problems of cognitive development. This limitation ignores the possibility of understanding the 'larger social unities' and their implications. Further analysis along these lines seems essential if

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[22] Ibid., p. 3.

[23] J. J. Goodnow and G. Bethon, "Piaget's Tasks: Effects of Schooling and Intelligence", Child Development, 1966, 37, 573-582.

[24] H. B. Hood, "An Experimental Study of Piaget's Theories of the Development of Number", British Journal of Psychology, 1962, 53, 273-286.

[25] M. Woodward, "The Behavior of Idiots Interpreted by Piaget's Theory of Sensori-Motor Development", Journal of British Educational Psychology, 1959, 29, 60-71.

[26] H. Werner, "Functional Analysis in Mentally Deficient Children", American Journal of Abnormal and Social Psychology, 1939, 34, 37-62.

the nature and degree of 'social determination' of mental retardation is to be more effectively analyzed and courses for remediation made available.

Issues in this Investigation

Studies in developmental psychology suggest the possibility of developing an ordinal scale for assessment of mental growth, rather than the present practice of evaluation of individuals in terms of rank order or position in a group assumed to be homogeneous because of age. It is clear from studies of child growth and development that individuals grow, develop and learn at different rates. An ordinal scale would provide for effective individual assessment of mental function. Such an investigation must take into account the socio-cultural variables which are currently widely accepted as related to mental growth.[27, 28]

In Piaget's genetic epistemology, cognitive development is aimed at culmination in logical or hypothetico-deductive thought. Logical thinking is viewed as the end of an evolutionary process in which there is a fusion of the operations of classification and seriation.[29] This process is conceptualized as beginning with sensorimotor development, evolving through the stage of perception and prehension of objects that

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[27] M. Deutsch, et al., The Disadvantaged Child (Basic Books, Inc., New York, 1967).

[28] F. Reissman (Ed.), The Culturally Disadvantaged Child (Harper and Row, New York, 1962).

[29] J. Piaget, Six Psychological Studies (Random House, New York, 1967).

are close and are seen as static by the child. In time, memory and practical intelligence permit representation of earlier states of objects and anticipation of their future states. This is, in turn, subsequently reinforced by intuitive thought and, ultimately, logical thinking. This evolutionary process is terminated via the experience of concrete operations and abstract deductions. In this genetic theory it is assumed that the function of mental mechanisms in the child best explains their nature and function in the adult. Logic is said to be evidenced in the operational structures (acting on things and towards people) in the ultimate interactions of the basic operations of classification and seriation.

Classification, the process of grouping, is a basic operation in this system, which has been the object of numerous studies directed toward both the measurement of and training in this process.[30,31] The relationship of classification to psychological interest in concept formation and the significance it bears to current work in linguistics may have been responsible for the apparent over-emphasis on this operation as seriation appears to be relatively neglected in the research literature.

Seriation, the process of ordering, is an operation which parallels classification and is of equal importance in the early growth

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[30] J. W. Gallagher, "Productive Thinking" in M. L. Hoffman and L. W. Hoffman (Eds.), Review of Child Development Research, Vol. 1 (Russell Sage Foundation, New York, 1964) pp. 349-382.

[31] M. S. Wallach, "Research on Children's Thinking" in H. S. Stevenson (Ed.), Child Psychology: 62nd Yearbook of the National Society for the Study of Education (University of Chicago Press, Chicago, 1962) pp. 236-276.

of logic.[32] However, this operation has been the subject of very few studies. It is only within the last year that work has been reported which offers promise of providing techniques for the measurement of and direction for training procedures in the process of seriation.[33] As a basic and essential operation for the development of logical thinking, the need for further understanding of the nature of seriation is apparent.

Inhelder and Piaget suggest that seriation is, perhaps in major part, related to perceptual development. They explicitly establish the similarity between perceptibility of size differences and the manifestation of seriation in the child.[34] In conclusion, they say that "Seriations correspond closely to a highly acceptable 'good' perceptual form, unlike classifications which do not".[35] Questions of the relationship between imagery and thinking follow from this formulation.

The relationship between perceptual development and activity to intellectual growth remains ambiguous because the typical approach has been to study each process in isolation. The history of experimental psychology was founded on studies in sensory discrimination and

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[32] See Definition of Terms and Chapter II, Review of the Literature for further elaboration of this concept.

[33] J. W. Nelson, Construct Validation of the Learning Readiness System-Seriation Test (Unpublished Doctoral Dissertation, Indiana University, 1968).

[34] B. Inhelder and J. Piaget, The Early Growth of Logic in the Child: Classification and Seriation (Routledge and Kegan Paul, London, 1964) p. 269.

[35] Ibid., p. 290.

perception of relations.[36] But this stream has remained relatively independent from the movements addressed to the investigation of child development and mental growth. The connection between perception and intelligence assumes a very practical significance if interest is to be directed toward stimulating intellectual growth.

In the framework of Piaget's theory, perception is not on the continuum of growth from sensorimotor intelligence to cognition, but is rather an independent and parallel line.[37] Werner, on the other hand, describes continuity and overlap through successive stages of sensorimotor, perceptual, and cognitive development.[38]

Clearer delineation of seriation, an essential component of logical thinking, as it relates to perception may provide linkage between the heretofore largely independent dimensions of thinking and imagery. Further evidence relative to this issue and developmental theory has important implications for educational practice.

SIGNIFICANCE OF THE STUDY

The application of genetic, developmental theory to the study of mental structure and functioning offers promise for providing techniques for the assessment of an individual relative to his position on a

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[36] E. G. Boring, Sensation and Perception in the History of Experimental Psychology (D. Appleton-Century Co., New York, 1942) pp. 1-45.

[37] J. H. Flavell, The Developmental Psychology of Jean Piaget (D. Van Nostrand Co., Princeton, New Jersey, 1963) p. 232.

[38] H. Werner, op. cit., (Comparative Psychology of Mental Development) pp. 5-6, 15.

developmental scale. This appears to be preferable to the ubiquitous practice of psuedoquantitative measurement based on comparison with a standardization group. The possibilities of achieving such ordinal measurement imply practical consequences for remediation and education which have not ensued from the normative evaluations. Further clarification on the process of mental development should offer direction for educational planning and practice. It might also elucidate the relationship between perceptual development and the evolution of intellection or logical thinking.

Dunn[39] and Kirk,[40] among others, present an abundance of evidence that past and present practices in the use of psychological evaluations in the schools are not primarily designed to meet the pupils' needs.[41] It is said that these evaluations have their major justification in the establishment of special classes which remove pressures on regular teachers and students at the expense of the socio-culturally disadvantaged, slow-learning pupils themselves. Dunn estimates that there are 32,000 teachers of the mentally retarded employed by local school districts in the United States, of whom over two-thirds provide for pupils of low status background.[42] This includes Afro-Americans, American-

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[39] Dunn, op. cit.

[40] S. A. Kirk, Public School Provision for Severely Retarded Children (Interdepartmental Health Resources Board, Albany, New York, 1957) 87 pp.

[41] This condition is perpetuated by the fact that, in most states, financial aid from the state is available to reimburse school districts for the cost of certifications for special class placement. In California, a major portion of salaries paid for psychological services derives from this source, shaping the nature of psychological services.

[42] Dunn, op cit., p. 18.

Indians, Mexicans, and Puerto Ricans in disproportionately large number. Further information about this population is essential if policy, in the absence of any definitive knowledge about the inheritance of capacity, is to be based on more promising assumptions about human nature and mental development.

Further, the study of structure of the intellect in the mentally retarded has implications for diagnostic purposes. The distinction made by researchers and practitioners between the types of retardation related to "organic" and "familial" (more recently, "brain damaged" and "undifferentiated") has been of questionable validity and doubtful utility. The most promising approach for differential diagnosis, presently of greatest interest, is in terms of perceptual and visuo-motor disturbances, reported to be more frequently associated with retardation in individuals known to have some neuropathological disorder.[43]

The data collected in this study on the development of seriation and perception and the relationship between them, the relationship of these dimensions to intelligence and achievement, and the statistical analysis of these factors in terms of socio-economic and ethnic background of the students adds to the existing body of knowledge and further clarifies variations in function among the mentally retarded as these differences are related to clinical, diagnostic information.

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[43] See discussion in Chapter II, Review of the Literature, under heading "Diagnostic Implications of Perceptual Handicap".

PURPOSES OF THE STUDY

Since seriation and perception are concepts developed through both theory and tests,[44] the collection of data on the development of these concepts, with analysis of these measures as related to intelligence and achievement test scores, is designed to add to the existing body of knowledge and provide clarification relevant to substantive and theoretical problems in the population designated as "Educable Mentally Retarded". Specifically, this study is addressed to providing a descriptive analysis of seriation in this group of students. Analysis of the data is directed to the following questions:

1. What is the relationship between seriation and perception among the retarded?
2. What is the relationship between seriation and intelligence as measured by tests among the retarded?
3. What is the relationship between socio-cultural and ethnic background variables to seriating and perceptual abilities among the retarded?
4. What is the relationship between perception and intelligence among the retarded?
5. What is the relationship of the factors which differentiate groups (based on socio-cultural and ethnic factors) among the retarded to the major dimensions of academic achievement?

The variables under consideration in this study are of great interest in current educational research: Intelligence, aptitude, ethnic origin, and social class membership. These are incapable of being manipulated for purposes of experimental inquiry. However, controlled inquiry, with particular attention to the possible sources of

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[44] Cf. infra., pp. 30-52.

variance in a factorial analysis of variance design, yields highly useful and relevant data on these questions.[45]

In addition, this type of study provides a significant segment of information for further evaluation of the Learning Readiness-System Seriation Test.[46] The relative homogeneity of the population under consideration imposes limitations on the generalizability of the findings. Nonetheless, the data applicable to the empirical or construct validation of psychological tests have relevance to the theory behind the tests. Piaget's theory of cognitive development provides the basis for the Seriation Test; the findings in this study have theoretical significance in this regard. Moreover, the design of the study takes into account the 'larger social unities' conceptualized in Werner's term 'ethnopsychology'[47] in the effort to establish a basis for effective differentiation among the heterogeneous population described as "Educable Mentally Retarded".

DEFINITION OF TERMS

Terms may be used with somewhat differing connotations according to theoretical viewpoint or context. Such terms, applicable to this study, are defined as follows:

1. Development: Implies movement and growth toward increasing differentiation of structure and function, with increased hierarchic organization.[48]

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[45] Cf. infra., Chapter III, Design of the Study.

[46] G. C. Helmstadter, Principles of Psychological Measurement (Appleton-Century-Crofts, New York, 1964) pp. 112-256.

[47] Cf. supra., p. 8.

[48] Ibid.

2. Ethnic: Pertaining to, or characteristic of, a people, especially to a speech or culture group. Referring to the cultural, racial, religious or linguistic traditions of a people or country.[49] For purposes of this study, children of mixed or uncertain parentage and all Oriental children were excluded from the research sample.

3. Intelligence: Refers to academic aptitude, ability primarily associated with scholastic achievement.[50] In this study, this process is hypothesized and inferred from individually administered tests, either the Wechsler Intelligence Scale for Children or the Stanford-Binet, Form L-M.

4. Mental Ability: The aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment.[51] (This is Wechsler's definition of intelligence, but is used in this study inclusive of evidence of maturity outside the testing situation).

5. Mental Retardation: Refers to subaverage general intellectual functioning which originates during the developmental period and is associated with impairment in adaptive behavior.[52] This carries no implications as to etiology or prognosis.

6. Perception: A single unified awareness derived from sensory processes while a stimulus is present; the act or faculty of apprehending by means of the senses or the mind.[53]

7. Seriation: An operation enabling the ordering of stimuli according to size, pattern, etc. Operational seriation implies transitivity (i.e., C > A if B > A and C > B). It is the

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[49] The Random House Dictionary of the English Language (Random House, New York, 1966) p. 489.

[50] A. R. Jensen, "Patterns of Mental Ability and Socio-economic Status" (Paper presented at the Annual Meeting of the National Academy of Sciences, Washington, D. C., April 24, 1968).

[51] D. Wechsler, The Measurement and Appraisal of Adult Intelligence (Williams and Wilkins, Baltimore, 1958, 4th ed.) p. 7.

[52] R. Heber (Ed.), "A Manual on Terminology and Classification in Mental Retardation" Monograph Supplement, American Journal of Mental Deficiency, 1958, 64, No. 2. This is also the official definition, adopted by the American Association on Mental Deficiency in 1959.

[53] Random House Dictionary, op. cit., p. 1069.

additive arrangement of asymmetrical transitive relations which recognizes their reversibility. The process is inferred from behavior which implies representation and anticipation of order, and evolves in stages in child development from about age four to seven.[54]

8. Socio-economic Status: The status in a particular society deriving from a combination of social and economic factors related to income and social position. For purposes of this study, the occupation of the pupil's father (or mother, if father is absent from the home) and type of housing are used as determiners of this status (See Appendix A.). Warner et al., indicate that these are the most useful characteristics for this purpose.[55]

SUMMARY

The first chapter of this report has outlined a multifaceted problem and delineated the present study. Investigation of any factor in the population designated as 'mentally retarded' is beset by the ambiguities and difficulties inherent in the nature of this loosely defined entity. More particularly, the problems associated with the nature of the assessment process itself and the placement of public school pupils in special classes have been described. The relationship of these problems to current issues in education regarding the failure of public schools in the United States to meet the needs of students from the lower socio-economic levels, who constitute the major portion of students in the special classes, has been pointed out.

Developmental psychological theory, particularly in terms of

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[54] Inhelder and Piaget, op. cit., pp. 249-275.

[55] W. L. Warner et al., Social Class in America (Science Research Associates, Chicago, 1949) pp. 139-142.

Piaget's conceptualization of intellectual growth, has been suggested as offering a productive approach to the study of multiple problems in this area. This investigation is directed to gathering base line data to increase the bodies of knowledge dealing with: (a) Cognitive development, with particular reference to seriation and perceptual ability and (b) Empirical studies on the structure and function of the intellect in the mentally retarded, with particular attention to the possible sources of variance in the functioning among this group.

Further study of the development and operation of seriation in the Educable Mentally Retarded yields evidence relevant to both substantive and theoretical problems in psychology and education. The data obtained in this study is treated (by statistical analysis of the independent and interactive effects of ethnic origin, social class membership, intelligence, age, and sex on seriating ability and perceptual development) to provide (a) theory building on the nature of mental growth and (b) directions for the improvement of assessment procedures and programs for remediation and education for this population, which is burdened with multiple disadvantages.

CHAPTER II

REVIEW OF THE LITERATURE

There is a voluminous body of literature pertinent to the multiple aspects of this investigation. This summary is limited to the issues considered by the author to be most salient to this study.

The major approaches to the study of the nature of intelligence and perception are briefly reviewed. The literature on seriation is summarized and, finally, the current work, which sharpens the focus on the nature-nurture problem as it relates to social class and ethnic origin, is also outlined.

THE NATURE OF INTELLIGENCE

The need for more adequate linkage between psychometrically based theories and general psychological theory was indicated in the discussion of the problem in this investigation. The longtime popularity of the 'operational' definition of intelligence as being what is measured by intelligence tests is sufficient evidence that the technology of testing was far in advance of any scientific theory about the nature of what was being measured. It is generally conceded that the history of the intelligence testing movement, as well as the other major approaches to the study of intelligence (statistical and mental growth

studies) must be taken into account.[56,57,58]

The Psychometric Tradition

The earliest attempts to measure intelligence reflected the traditional associationism of philosophical origin and interest in physiological psychology which attended the birth of experimental psychology. The impact of Darwin's work and its implication for the significance of individual differences also had an influence on the mental measurement movement. The point is well made, however, that although attempts at measurement date from 1880, 'intelligence' was not defined in the psychological dictionaries until 1901.[59]

Based on the idea that the only information which comes to people concerning the world reaches them through the senses, the first measures of intelligence were psychomotor and sensory thresholds. Galton's anthropomorphic testing laboratory, established in 1882, was organized on these lines.[60] James McKeen Cattell developed tests on sensory and and perceptual processes predicated on the idea that the more perceptive

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[56] F. Goodenough, "The Measurement of Mental Growth in Young Children" in L. Carmichael (Ed.), Manual of Child Psychology (John Wiley and Sons, New York, 1954, 2nd ed.) pp. 459-491.

[57] J. P. Guilford, The Nature of Human Intelligence (McGraw Hill Book Co., New York, 1967) pp. 2-20.

[58] R. P. Pintner, Intelligence Testing: Methods and Results (Henry Holt and Co., New York, 1932) pp. 60-71.

[59] R. D. Tuddenham, "The Nature and Measurement of Intelligence" in L. Postman (Ed.), Psychology in the Making (Alfred A. Knopf, New York, 1962) pp. 469-525.

[60] Pintner, op cit., p. 17.

the senses, the larger the field on which judgment and reason can act.[61] Binet similarly looked to sensory tasks to assess learning ability of children. Finding that these were inadequate, he added to tasks of motor skill and judgment of visual space, the more complex processes of reasoning, judgment, and ability to adapt.[62]

Intelligence seems to have been given definition in the accretion of test ideas: reasoning, judgment, problem solving, and capacity for adaptation and learning. Tuddenham says that Binet never defined intelligence[63] but Pintner points out that the definition was made in the manner of faculty psychology, by the addition of attributes.[64] Terman's concept of the equivalence of intelligence and abstract thinking is also in the category of a faculty psychology type of definition.[65]

The psychometric tradition appears to have been largely responsible for the popular conception that intelligence is learning ability. This derives from the fact that the testing movement developed in response to urgent pressures and needs in education; it flourished because it demonstrated its social utility by meeting these needs. The tests devised by Binet and Terman became the standard against which other

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[61] Ibid., p. 19.

[62] Tuddenham, op. cit., p. 481 et seqq.

[63] Ibid., p. 489.

[64] Pintner, op. cit., p. 49.

[65] Ibid.

tests of mental ability were evaluated.[66]

Experimental and Statistical Methods

The concept that intelligence and academic learning ability are equivalent is now challenged on a broad front. The idea, says Guilford, "that intelligence is learning ability and that it is a universal ability, regardless of the thing being learned, has been definitely exploded."[67] Guilford and his associates, working from factor analytic studies in developing the "structure of intellect theory", reject the unitary concept of a global intelligence in favor of approximately eighty factors already identified and an additional thirty predicted by the theory as presently constituted.[68] A three dimensional model is constructed (to allow for interaction) based on the inferred "operations, contents, and products" of mental function. Much emphasis is placed on the differences between convergent thinking (related to processes measured by standard intelligence tests) and divergent thinking (associated with innovative and creative mental activity).

Guilford acknowledges Spearman as the "father of factor analysis".[69] Spearman, more than forty years ago, reported finding multiple aptitudes, and represented each ability as the product of 'g' (general ability providing for intercorrelation among different tests) and 's'

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[66] J. P. Guilford, The Nature of Human Intelligence (McGraw Hill Book Co., New York, 1967) pp. 4-11.

[67] Ibid., p. 20.

[68] Ibid., pp. 70-250.

[69] Ibid., p. 56.

(a unique, specific ability).[70] The two operations most characteristic of 'g' are the "eduction of relations" and the "eduction of correlates". (Measures of intelligence commonly use analogies and similarities type items to include these operations.)

Burt proposed an idealized hierarchical model for ability factors, with successive dichotomization possible at each level of mental operation.[71] The levels are described as (1) simple sensory and motor processes; (2) complex perceptual and motor processes; (3) associative or reproductive level (including imagery, mechanical memory and habit formation) and (4) relational level with generalization by concepts (abstraction), generalization by propositions (judgments), and relational inference (reasoning).

Another model based on 'g' plus 'major' and 'minor' processes is presented by Vernon.[72] The major factors are (1) verbal-educational and (2) practical (which subdivides into space ability, manual ability, and mechanical information). The minor factors here are specific, of narrow scope, and treated as being of little importance.

A somewhat different concept of a hierarchy, or levels of ability, is also present in the theory proposed by Jensen to account for the empirical findings in a study of the interaction of intelligence,

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[70] C. Spearman, The Abilities of Man (MacMillan Co., New York, 1927).

[71] C. Burt, "The Structure of the Mind: A Review of the Results of Factor Analysis", British Journal of Educational Psychology, 1949, 19, 100-111, 176-199.

[72] P. E. Vernon, The Structure of Human Abilities (John Wiley and Sons, New York, 1950).

learning ability and socio-economic status.[73] The findings were that children of lower socio-economic status evidenced significantly greater impairment on standard intelligence tests than on the 'learning tests'. (These were laboratory tests for serial and paired associate learning.) Jensen concludes that there is a continuum of ability tests going from the simplest associative learning to conceptual problem solving. This continuum is described as the "phenotypic expression of two functionally dependent but genotypically independent types of mental processes". These are, however, so polarized that they are designated as "Level 1" and "Level 2" abilities. The rate and asymptote of phenotypic development for the transformations and complex operations required on the usual verbal (and even some of the non-verbal) intelligence tests depends on the individual's development on the simpler, associative processes.

Cattell offers a theory of fluid and crystallized intelligence to account for differential abilities on the various factors which he infers from factor analytic studies.[74] Fluid intelligence refers to broad, general abilities which are manifested in adaptability to new situations. Crystallized intelligence is further exercised and developed in the application of the earlier, broad general abilities to learning situations.

A dichotomy of abilities is also presented in the work of

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[73] Jensen, op. cit.

[74] Cattell, op. cit.

Wallach and Kogan in their analysis of cognition in young children.[75] They propose a dichotomy of associative and evaluative thinking (in many ways a parallel to Guilford's divergent and convergent processes). But Wallach and Kogan acknowledge:

> ...the fact that different intellectual abilities are appreciably intercorrelated does suggest the existence of some common domain of individual variation, and it is the fact of such intercorrelation that justifies assigning a single label, such as 'intelligence' to this domain.[76]

This is essentially the scientific warrant for the consideration of intelligence as an entity, however ambiguous and debatable its definition may be.

The factor analysts have built their case on the grounds that the work of the psychometrists has failed to generate either psychological theory or information about basic concepts. The case against the factor analysts is effectively summarized by Tuddenham:

> ...the very proliferation of factors has reduced them from hypothetical constructs to mere intervening variables, and robbed the factor theory of the claims to elegance and parsimony which had been its basic justification. Test constructors will continue to employ factorial procedures, provided they pay off in improving the efficiency and predictive value of our test batteries, but the hope that factor analysis can supply a short inventory of 'basic abilities' is already waning.
>
> The continuous difficulties with factor analysis over the last half century suggest that there may be something fundamentally wrong with models which conceptualize intelligence in terms of a finite number of linear dimensions. To the statistician's dictum that whatever exists can be measured, the factorist has added the assumption that whatever can be 'measured' must exist. But the relationship may not be reversible, and the assumption may be false. Is there an alternative?[77]

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[75] M. A. Wallach and N. Kogan, Modes of Thinking in Young Children (Holt, Rinehart and Winston, New York, 1965).

[76] Ibid., p. 2.

[77] Tuddenham, op. cit., p. 516.

Mental Growth Studies

The alternative to the factor analytic method may lie in the other major approach to the study of mental growth which is represented by (a) research measuring increase in performance as a function of age[78] and (b) developmental psychology.[79] Tuddenham's question of an alternative to factorial methods is rhetorical. He suggests the differentiation of content (what has been learned) and process (how efficiently learning takes place).[80] Similarly, McNemar has stressed the need for understanding the process aspects of intelligence.[81] Mental growth studies appear to move in this direction in that the age normative research clearly deals with acquisition of content and the genetic studies focus on the process aspects of intellectual development.

The work of Piaget and his associates, which is most productive in theory building and stimulating research, is of direct concern to the present investigation. Piaget's view that understanding how knowledge is acquired and used is the key to understanding intelligence is clearly process oriented.[82]

In Piaget's formulation of cognitive development, the infant

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[78] F. Goodenough, op. cit., provides a review of the age normative studies.

[79] Cf. infra., pp. 32-35.

[80] Tuddenham, op. cit., pp. 516-521.

[81] Cf. supra, p. 7.

[82] J. Piaget, Six Psychological Studies (Random House, New York, 1967).

begins life with bodily structures capable of only a few reflexes.[83] It is on the bases of these innate 'schemas' (organized sensorimotor sequences) that all knowledge is acquired. The methods for schema building are twofold: assimilation (incorporating new elements from the sensory inputs) and accomodation (self-adjustment or modification of existing structures to permit more effective adaptation for new additions).

Because of the major interest in intellectual development, this system is generally described as a 'cognitive psychology'. But the systematic emphasis on sensorimotor activity is consonant with behavioristic systems, particularly in the conception of thought as internalized action, as indicated in this statement:

> All knowledge of objects is a function of those action schemata to which the object is assimilated; and these range from the earliest reflexes to the most complex elaborations acquired by learning.[84]

Piaget himself describes his system as a "functional mechanism" in which all mental life tends progressively to assimilate the surrounding environment as the scope of action of the structures or psychic organs becomes more extended. This, in essence, constitutes the "dynamic equilibration" theory which provides the growth principles governing both the acquisition of knowledge and the structures necessary for this acquisition.[85]

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[83] J. Piaget, The Origins of Intelligence in Children (International Universities Press, New York, 1952).

[84] Inhelder and Piaget, op. cit., p.6.

[85] Ibid., Chapter 2.

Piaget describes stages of development in the child as a continuum of transition from sensorimotor activity to formal logic. This transition is sequential and invariant; the ages given are approximate and significant of the age to the stage is minimized.[86]

1. Sensorimotor stage: In which the child is dominated by perceptual learning, to about age 2.

2. Pre-operational stage: (a) Representational phase, in which the earlier presentation of objects is recalled and anticipation of future events emerges, to about age 4; and, (b) Intuitive phase, in which the fundamental operations appear and child can think in classes, see relationships among objects, and handle simple number concepts, to about age 7.

3. Concrete operations: Classification and seriation are fully operational, i.e., reversibility, transitivity, and conservation are manifested, to about age 11.

4. Formal operations: Abstract thinking and hypothetico-deductive thought develop in age group 11 to 15.

This is an organismic-experiential system, in which the interaction of the individual and his environment is made explicit in its relevance to growth. However, there remain unanswered questions about whether and to what degree external influences, such as home environment or teaching, may effect stage development.[87, 88, 89] In a

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[86] Ibid., Chapter 6.

[87] J. W. Nelson, op. cit.

[88] E. A. Peel, "An Experimental Examination of Some of Piaget's Schemata Concerning Children's Perception and Thinking and a Discussion of Their Educational Significance" British Journal of Educational Psychology, 1959, 29, 89-103.

[89] I. E. Sigel, "The Attainment of Concepts" in M. L. Hoffman and L. W. Hoffman (Eds.) Review of Child Development Research, Vol. 1 (Russell Sage Foundation, New York, 1964) pp. 209-248.

review of this work, Bruner also notes that the theory lacks comprehensiveness in that it fails to account for the goals for which people strive and ignores the broader motivational changes which shape behavior.[90]

PERCEPTION

In an analogue to the problem of the nature of intelligence, perception seems best understood by refernce to the approach taken in studying it. The philosophical biases and the theoretical views of the investigator determines the definition, the taxonomy, and, to a large extent, the findings of the researchers.[91, 92]

The study of sensation and perception have been of central concern in the history of psychology as they are related to the individual's apprehension of the world around him.[93] In general, the questions raised have to do with: Why does something 'look' like it does? Why doesn't the same thing 'look' the same to all people?[94] Spivack notes that there has been increased attention to perception:

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[90] J. S. Bruner, "Inhelder and Piaget's The Growth of Logical Thinking: I, A Psychologist's Viewpoint", British Journal of Psychology, 1959, 50, 363-370.

[91] W. M. O'Neill, "Basic Issues in Perceptual Theory", Psychological Review, 1958, 65, 348-359.

[92] J. J. Wohlwill, "From Perception to Inference", in W. Kennen and C. Kuhlman (Eds.), Monograph of Society for Research in Child Development, 1962, 27, (2) 87-107.

[93] Boring, op. cit., pp. 1-78.

[94] Although 'perception' and research in it include all sensory modalities, the preponderance of studies are concerned with visual effects.

> ...stimulated by issues such as the effects of needs or values on perceptual responses, the potency of stimulus qualities and cognitive attitudes in determining the extent of play of central factors, and more recently, the question of what is learned in perceptual learning situations.[95]

Thurstone reported an exploratory study to determine whether perceptual effects which appear to be central (rather than ocular) in nature are related by any functional unity.[96] In the factorial analysis of perception, he reports four such "functional unities": perceptual closure, reaction time, speed of perception, and speed of judgment. Further investigation which related these findings to the composite tests of primary mental ability indicated a second order general factor, suggesting the "relative independence of the perceptual functions in the present battery from the cognitive functions involved in various aspects of intelligence".[97]

Philosophical Issues

The issues on which differences are centered in the study of perception are: the ubiquitous nature-nurture and empiricit-nativist controversies; if the perceptual process is learned, how does the learning take place; the epistemological problem of whether there is an externally existing object or only a representation of it; and a range in focus of interest on the environmental part (ranging from object to

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[95] G. Spivack, "Perceptual Processes", in N. R. Ellis (Ed.), op. cit., p. 480.

[96] L. L. Thurstone, A Factorial Study of Perception (University of Chicago Press, Chicago, 1944).

[97] Ibid., p. iv.

proximal stimulus) and on the organism (from stimulus to environment).[98, 99]

The typical treatment of perception and cognition as independent processes reflects the philosophical dualism on the mind-body issue. Interactionist theories involve the insubstantial and paradoxical mind, which science eschewed in favor of a more orderly system.[100] There is, however, an increasing tendency to unite these processes. Many authorities acknowledge that normal perception is to some degree a function of cognitive inferences based on knowledge of what is perceived and that cognitive functioning develops through the course of the child's actions and perceptions.[101]

Perception and Environment

The issues of heredity and environment and the relationship of maturation and learning to perceptual development are most relevant to this investigation. Guilford says about this:

> It is no longer a question of which is the right view and which is the wrong one but of how much and what comes by way of natural growth and what is the role of stimulation and experience.[102]

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[98] O'Neill, op. cit.

[99] F. Heider, "On Perception, Event Structure and the Psychological environment", in G. S. Klein (Ed.), Psychological Issues (International Universities Press, New York, 1959) pp. 1-121.

[100] Boring, op. cit., pp. 53-78.

[101] A. H. Kidd and J. L. Rivoire (Eds.), Perceptual Development in Children (International Universities Press, New York, 1966) p. 389 et seqq.

[102] J. P. Guilford, The Nature of Intelligence (McGraw Hill Book Co., New York, 1967) p. 261.

The research evidence supports modification of perception by environmental and experiential influences. In their review of the literature on innate versus learned visual perception, Zuckerman and Rock conclude that color discrimination and form perception have an innate basis, but that experience contributes to the development of the innate powers and adds new ones.[103]

Fantz has used the visual preference method, observing and recording infants' direction of gaze and visual fixations, to demonstrate perceptual capacity and selectivity as early as the sixth day of life.[104] Gibson devised an apparatus, the "visual cliff", to show that infants just beginning to crawl retreat from the apparent drop.[105] In a study of chicks kept in darkness five days after hatching, Riesen found more accurate pecking than in newly hatched chicks.[106] This suggests the development of pattern vision without visual practice. However, he also reports that chicks who were kept in darkness for fourteen days did not peck at all, indicating an atrophy of this ability without some exercise within a time limit.

White and his colleagues report studies in which the sensory

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[103] C. B. Zuckerman and I. A. Rock, "A Reappraisal of the Roles of Past Experience and Innate Organizing Processes in Visual Perception", Psychological Bulletin, 1957, 54, 269-296

[104] R. L. Fantz, "The Origin of Form Perception", Scientific American, 1961, 204, 66-72

[105] E. J. Gibson, "Perceptual Development" in H.S. Stevenson (Ed.), Child Psychology: 62nd NSSE Yearbook, Part I (University of Chicago Press, Chicago, 1963) pp. 144-149.

[106] A. H. Riesen, "Arrested Vision", Scientific American, 1950, 183, 16-19.

experience of a group of institutionalized infants was enriched by the addition of figured sheets and stabiles attached to the crib.[107] In the institutional setting, it was possible to maintain experimental and control groups, varying conditions by using stabiles of varying complexity, introduced at different points (day 37 through day 124). This study clearly shows that the addition of visual stimulation affects the timing of acquisition of visual-motor responses as measured by visually directed reaching. Although no scientific conclusion with regard to later perceptual or perceptual-motor development may be drawn, it follows that if the developmental hypothesis that further growth is based on prior skills is valid, a stimulating visual environment promotes earlier development.

Studies on the effects of sensory deprivation have added appreciably to understanding environmental stimulation in relation to perceptual function. Hebb reported that for several days after the experimental condition of extreme sensory deprivation (lasting one to three days) college students, serving as volunteer subjects, complained about feeling apathetic, listless, lacking in motivation, and unable to concentrate.[108] Hebb proposes that the absence of a constantly varying stimulus environment impairs the arousal function of the reticular system, resulting in later resistance to sensory input and perceptual activity.

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[107] B. L. White et al., "Observations on the Development of Visually Directed Reaching", Child Development, 1964, 35, 349-364.

[108] D. O. Hebb, "The Motivating Effects of Exteroceptive Stimulation", American Psychologist, 1958, 13, 109-115.

The assumption in clinical work with projective tests is that each individual perceives the world in terms of his own needs and personality, interpreting and ascribing meaning to ambiguous stimuli.[109] An ingenious study by Levine et al., demonstrated that the manipulation of attention or set can influence perception.[110] Ambiguous pictures were presented to two groups of subjects, one of which had been deprived of food. The hungry group produced many more food labels than the other. The link between perception and experience of the individual lies in the fact that whatever influences mold personality also play a role in perception.

Perceptual Development

Gibson describes developmental aspects in perceptual function beginning with space (i.e., surfaces, edges, and places which make up the environment), then encompassing objects proper (detachable solids), progressing to two dimensional representation of objects, and then to non-representative and "coded" stimulus sources, such as in reading and writing.[111] This is proposed within a maturational system in which learning is limited to the "discovery of the dimensions of differences" and "education of attention".

Others conceptualize development in quite different terms.

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[109] F. McFarland, The Diagnostic Significance of Fable Completion by Children (Unpublished Master's Thesis, Stanford University, 1949).

[110] R. Levine et al., "The Relation of the Intensity of a Need to the Amount of Perceptual Distortion", Journal of Psychology, 1942, 13, 283-293.

[111] E. J. Gibson, op. cit., pp. 186-190.

Wohlwill focuses on the changes in the stimulus to evoke the appropriate response.[112] Piaget gives learning, as such, explicit significance:

> ...the maturation of the nervous system can do no more than create the conditions for a continual expansion of the field of possibilities. The realization of these possibilities demands not only the action of the physical environment (practice and acquired experience), but also the educational influences of a favourable social environment.[113]

In accord with the developmental hypothesis of growth toward greater differentiation and hierarchical organization, it is expected that perceptions of younger children are relatively global and diffuse. With age, the ability to analyze and recognize percepts is related to the cognitive structuring of experience. This is supported by the studies of Ames et al., on the differences in perception of Rorschach inkblots as a function of age.[114] Two year olds tended to see the blots as wholes, naming them as objects. By age three, children began to perceive major details and attempted organization of the blots. Similarly, the trend is clear throughout childhood.

While visual-motor behavior is a composite, it provides one of the most popular methods for assessment of perceptual function as part of the child's information processing system. As Beery notes:

> Intelligence and academic achievement are founded upon well-developed information-processing systems; that is,

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[112] Wohlwill, op. cit., pp. 98-102. (Cf. infra. pp. 39-40.)

[113] Inhelder and Piaget, op. cit., p. 5.

[114] L. B. Ames et al., Child Rorschach Responses; Developmental Trends from Two to Ten Years (Paul B. Hoeber, New York, 1952).

> a child's ability to read, write, and spell depends upon his abilities to see, hear, feel, speak, and move...(He) must record, analyze, and transmit data.[115]

Beery's test manual is a compilation of the age normative data available for visual-motor tasks. This manual reports a clear progression in the ability to copy increasingly complex figures in the course of development.[116]

Elkind et al., report a hierarchical order in the development of perception with regularity of increase with age for recognition of known words in modified form, the ability to recognize modified words correlated with reading achievement, and modified word recognition and reading achievement correlated with non-verbal measures of "de-centration".[117] They interpret their findings in terms of the decreased significance of the field effects and progress from dependency on the perceptual field to "perceptual regulations". These are defined as internalized sensorimotor acts, analogous to the operational system of abstract intelligence in that the grouping and regrouping of problematic elements is possible.

Although Piaget is better known for his work on intellectual

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[115] K. E. Beery, Developmental Test of Visual-Motor Integration: Administration and Scoring Manual (Follett Publishing Co., Chicago, 1967) p. 12.

[116] Ibid., pp. 11-66.

[117] D. Elkind et al., "Modified Word Recognition, Reading Achievement, and Perceptual De-Centration", Journal of Genetic Psychology, 1965, 107, pp. 235-251.

development, he has been extremely prolific in the study of perception.[118] Sequential development is described which permits the growing subject to play a more active and assertive role in his interaction with the environment. Perception, however, always remains relatively bound to time and space, although there is increasingly greater freedom from the primary field effects in the course of perceptual development.

Piaget maintains a sharp differentiation between sensorimotor and conceptual intelligence as opposed to perception.[119, 120] Flavell concludes his presentation of Piaget's work on perception by pointing out:

> Discussion of the development of perception as a progressive increase in perceptual activity raises once again the problem of the relation between perception and intelligence within Piaget's system. The developmental version of the problem is embodied in such questions as: What role, exactly, does the concomitant growth of intellectual structures play in this burgeoning of perceptual activity?--What, if any, reciprocal action does the growth of perceptual activity have on the evolution of the intellectual structures?--Is a distinction between these two adaptational forms really necessary, or are there data for which such a distinction is at least useful?[121]

Perception and Cognition

In Piaget's differentiation between the 'intellectual' and the

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[118] Most of Piaget's work on perception has been published in the "Recherches" series in Archives de Psychologie, Geneva, and is not translated or generally circulated here. The summary and interpretation by John Flavell (op. cit.), who is acknowledged as a "sympathetic spokesman and commentator" by Piaget in his Foreword to the book, is the best condensed source available for this part of Piaget's work.

[119] Inhelder and Piaget, op. cit., pp. 5-16.

[120] Flavell, op. cit., pp. 225-236.

[121] Ibid., p. 236.

'perceptual' as types of adaptation, perception applies to a restricted range of behavior, excluding any which involve more than a modicum of judgment, inference, classification, reorganization, etc. This is more than a semantic distinction. Perception is conceived as being a dependent subsystem within the larger context of the evolving sensorimotor intelligence. It is both developmentally subordinate and structurally inferior to intelligence as a class of adaptation.[122]

The mutual interdependence and interaction between cognitive and perceptual processes has been proposed by others. Vernon says most of the studies have been concerned with adults and tend to be specific to the situation presented, however, he states:

> ...children must acquire general and organized knowledge about the nature of the environment as a whole. They must also develop the capacity to attend and select, and to perceive rapidly and accurately, dependent in part on maturation but also assisted by learning. This learning, it may be supposed, is guided and reinforced by the consequences of actions stimulated by perception.[123]

He further suggests that the inability to direct attention appropriately to significant features of the environment is based on the lack of understanding of the nature of the situation.

Wohlwill proposes that perception and cognition can be related on three dimensions: (a) redundancy, with decreasing reliance on redundant stimulation in the course of development; (b) selectivity, with irrelevant information increasingly tolerated without impairing

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[122] Inhelder and Piaget, op. cit., pp. 12-16.

[123] M. D. Vernon, "Perception in Relation to Cognition", in A. H. Kidd and J. L. Rivoire (Eds.), op. cit., p. 392.

response; and (c) contiguity, with information increasingly freed of spatial and temporal limitations in the progression from perception to cognition.[124]

Bruner defines perception as "the generic term for complex sensory control of behavior as it is inferred from that behavior".[125] He elaborates the perceptual process as an act of categorization which is (a) a decision making process (b) utilizing discriminatory cues and (c) involving the operation of inference in categorization; these are (d) a set of specifications (e) varying in terms of their accessibility. This characterization appears to integrate perception and cognition effectively.

The studies and training programs of Frostig[126] and Kephart[127] are examples of work whose underlying assumption is that of unidimensional development from perception to cognition. In these, and other programs currently popular, remediation in perceptual-motor activity is related to improvement in ability and achievement.

Perception and Intelligence

The assumption generally underlying evaluation of perceptual competence in the child is that development involves physical and

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[124] Wohlwill, op. cit., pp. 98-102.

[125] J. S. Bruner, "On Perceptual Readiness", Psychological Review, 1957, 64, 123-152.

[126] P. Maslow et al., "The Marianne Frostig Developmental Test of Visual Perception", Perceptual and Motor Skills, 1964, 19, 463-499.

[127] N. C. Kephart, The Slow Learner in the Classroom (Charles E. Merrill Books, Inc., Columbus, Ohio, 1960).

psychological maturation, which are continuing and interactive processes. Perceptual adequacy is assessed to some degree any time an intelligence test is administered. Perceptual tasks were included by Binet in his original work[128] and have appeared in each Terman revision since 1916.[129] Reproducibility of figures presented visually and recall of visual experience is required in the subtests on the Wechsler performance scales for both children and adults.[130] Factorial studies of intelligence tests indicate that test batteries are comprised mainly of perceptual and motor tasks to age 3 or 4.[131]

Werner concludes that the development of optical percepts occurs through an increase in articulation.[132] He cites the work of Knoblauch on the problem of primitive organization in the perceptual field.[133] Groups of mentally defective children and normal children and adults were trained to respond to a solid, black circle set against an angular figure, then a variety of other figures were substituted in a test for discrimination. Children very low on the developmental scale based their choices more often on the qualities of blackness and solidity than on the figural qualities.

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[128] Cf. supra, p. 22.

[129] L. M. Terman and M. A. Merrill, Stanford-Binet Intelligence Scale, Manual for Third Revision, Form L-M, (Houghton Mifflin Co., Boston, 1960).

[130] Wechsler, op. cit., pp. 87-98.

[131] P. R. Hofstaetter, "The Changing Composition of 'Intelligence'; A Study of t-Technique", Journal of Genetic Psychology, 1954, 85, 159-184.

[132] Werner, op. cit., (Comparative Psychology of Mental Development), pp. 104-142.

[133] Ibid., pp. 115-116.

O'Connor and Hermelin reported that imbecile adults were less able than normal five year olds to recognize previously presented shapes visually, although in touch recognition, the imbeciles were superior to the normal children.[134] On a task requiring manual inspection of ten figures with conditions of either stereognostic or visual recognition versus visual inspection with similar alternative conditions of recognition, they found that normal children did not differ significantly between conditions, but mentally defective children did better on tactile tasks and surpassed normals on the like modality stereognostic recognition. The implication is that visual perception of shape is the more highly developed capacity and that retarded children are impaired in visual discrimination, but not stereognosis.

Spivack summarizes, on the basis of present research evidence:

> The results to date suggest that retarded S's as a group are less efficient than those with normal intelligence in the ability to make fine discriminations...and less able to recognize or identify complex stimuli when exposed for brief intervals...there is evidence that retardates with BI (brain injury) perform differently from NBI S's when confronted with these perceptual tasks.[135]

Diagnostic Implications of Perceptual Handicap

In a comparison of the performance of brain injured and familial retardates on the Stanford-Binet, Hoakley and Frazeur reported statistically significant differences between these groups on perceptual-motor

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[134] B. Hermelin and R. O'Connor, "Recognition of Shapes by Normal and Subnormal Children", British Journal of Psychology, 1961, 52, 281-284.

[135] Spivack, op. cit., pp. 500-501.

tasks.[136] These same authors compared "endogenous" and "exogenous" retarded boys on the Arthur Point Scale, finding the Porteus Mazes differentiated the groups.[137]

In the past two decades, research evidence has been abundant in this regard. Strauss and Lehtinen distinguished between these groups on the basis of "intrusion of the background in the figure" and developed the Marble Board Test for assessment.[138] This finding has been confirmed by Dolphin and Cruikshank for the cerebral palsied.[139]

The Bender Visual-Motor Gestalt has been used very often in studies of this population. Bender summarized her findings on cases with organic brain damage:

> These studies of disturbances in perceptual motor gestalten in organic brain damage indicate that the gestalt principles are never fixed, but are the integrative response of the personality-as-a-whole in any given situation; in disintegrating cerebral lesions they tend to revert to more primitive levels, and, as the brain recovers from the insult, they tend to follow the laws of developmental maturation in returning to the higher integrative responses.[140]

Koppitz offers a review of the research evidence and a scoring system

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[136] Z. P. Hoakley and H.A. Frazeur, "Significance of Psychological Test Results of Endogenous and Exogenous Children", American Journal of Mental Deficiency, 1945, 50, 263-271.

[137] H. A. Frazeur and Z.P. Hoakley, "Significance of Psychological Test Results of Exogenous and Endogenous Children", American Journal of Mental Deficiency, 1947, 51, 384-388.

[138] A. A. Strauss and L. E. Lehtinen, Psychopathology and Education of the Brain Injured Child, (Grune and Stratton, New York, 1947).

[139] J. E. Dolphin and W. M. Cruikshank, "The Figure-Background Relationship in Children with Cerebral Palsy" in E. P. Trapp and P. Himmelstein (Eds.) Readings on the Exceptional Child (Appleton-Century-Crofts, Inc., New York, 1962) pp. 508-514.

[140] L. Bender, A Visual Motor Gestalt Test and its Clinical Use Research Monograph No. 3, American Orthopsychiatric Association, New York, 1938) p. 76.

for the Bender, reporting that its value has been confirmed (especially for children) in differentiating organicity from other psychiatric disorders.[141]

Rose et al., reported that they differentiated between retarded children with "defective fetal development" and those with para or post-natal disease by comparing vocabulary score with performance on perceptual tasks.[142]

Using a somewhat different approach, Elkind et al., compared unmatched samples of brain injured and familial retarded children on the effects of perceptual training on ambiguous pictures.[143] They reported that the brain damaged took more trials to reach a lower level of post-training performance; but this reached statistical significance only when the mental age differential was controlled by analysis of covariance. They noted that the brain damaged child required a higher level of mental ability than the familial retardate to reach the same level of perceptual achievement. They argued that the practice of matching endogenous and exogenous groups for IQ introduced a systematic bias of sampling, because the mean IQ and distribution of scores in the two groups is different.

The work of Fitzhugh and his associates confirms that

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[141] E. M. Koppitz, The Bender Gestalt Test for Young Children (Grune and Stratton, New York, 1964) pp. 71-106.

[142] D. Rose et al., "Some Problems in Perceptual Handicap of Mentally Retarded Children", Journal of Genetic Psychology, 1964, 104 123-133.

[143] D. Elkind et al., "Effects of Perceptual Training on Unmatched Samples of Brain Injured and Familial Retarded Children", Journal of Abnormal Psychology, 1965, 70, 107-110.

sensorimotor measures of brain damaged subjects are significantly related to IQ scores (both using IQ as an independent variable and by correlational methods),[144] and suggests that differentiating between the retardates may be a function of the unequal means, as indicated by Elkind.

There is convincing evidence that differences in perceptual and visual-motor performance provide some basis for differential diagnosis between the brain injured and the undifferentiated retarded. However, the fact that perceptual competence and intelligence are related and tend to co-vary suggests again that analysis of the process is necessary to provide understanding and information to make training and educational programs more effective.

SERIATION

Seriation is defined as "the product of a set of asymmetrical transitive relations connected in series".[145] It is the process of ordering or arranging which is manifest in behavior of children in sorting, making piles of like objects, stacking blocks, nesting boxes, etc. Like classification, it is also one of the essential formatory mechanisms in the development of logical thinking. Inhelder and Piaget point out that the fact that seriating activity is seen in the sensorimotor and preverbal stages shows that the roots of these

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[144] L. C. Fitzhugh et al., Sensorimotor Deficits of Brain Damaged Subjects in Relation to Intelligence Level", Perceptual and Motor Skills, 1962, 15, 603-608

[145] Inhelder and Piaget, op. cit., p. 6.

structures are independent of language.[146] As further evidence of this, they cite evidence that seriation follows a similar course of development in deaf children.[147]

Logical reasoning in relation to classification and seriation develops before formal logical thinking, which involves the formation of systematic hypotheses and verification by deduction of their implications (i.e., the logic of propositions). The significance of classification and seriation lies in their invariant and sequential development and the fact that these processes must be fully operational in order to provide the necessary (but not sufficient) conditions for the emergence of hypothetico-deductive thought.[148]

The major difference between seriation and classification in this formulation lies in the fact that a relation can be perceived, whereas a class cannot. In spite of the perceptual "good form" constituted by a serial configuration (apparently simpler and more elementary than the structure of a matrix for classification), seriation does not become operational appreciably earlier than classification. The intuitive and operational factors relevant to the formation of the logical schemata in seriation are associated with the emergence of representation and anticipation in the child.

One of the studies reported by Inhelder and Piaget presents the relationship between anticipation and performance in seriation. For

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[146] Ibid., p. 14.

[147] Ibid., p. 3.

[148] Ibid., pp. 247-295.

children grouped by age, four to nine years old, failure in anticipation is clearly associated with failure in seriation, global anticipation with successful trial and error seriation, and analytic anticipation with operational seriation.[149]

Serial correspondence is described as being as easy as simple seriation. That is, a child who can build a series $A < B < C \ldots$, can also do $A_1 < B_1 < C_1 \ldots$ and $A_2 < B_2 < C_2 \ldots$ and he can report on the correspondence between A, A_1 and A_2. But the multiplication of asymmetrical transitive relations, involving a two dimensional series, with matrices along both horizontal and vertical axes, is much more difficult than the multiplication of classes. This is demonstrated in an experimental study in which groups of children were presented with 49 leaves, varying both in size and in shades of green.[150]

Seriation and Perception

It is clear that there is an immediate perception of symmetrical relations (when similarities are recognized) and of asymmetrical relations (differences). But operational seriation adds to the perceptual configuration in major factors: (a) Transitivity is a pre-inference which is implied in the series $3 > 1$ if $2 > 1$ and $3 > 2$, while perception is tied to the image: (b) From the operational point of view, the graphic representation is not essential; and (c) The transformation of asymmetrical transitive relations and the recognition of their reversibility makes seriation operational. For perception, only the

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[149] Ibid., p. 253.

[150] Ibid., p. 269, et seqq.

results of the transformations are meaningful. Inhelder and Piaget report that it takes children nearly as long to achieve operational seriation on the basis of perceptual configurations as it does to achieve operational classification.[151]

These authors suggest that while classification is closely related to language development, seriation is, at least in the early stages of development, a perceptually based process. The evidence of seriating behavior in preverbal children is offered to substantiate this.

Nelson reports, on the basis of his study of the Seriation Test:

> The pattern of factor loadings and intercorrelations lent some support, contrary to Piaget's expectations, to the interpretation that seriation predicts equally well either reading ability or arithmetic reasoning...while the relationship between seriation and verbal abilities seemed lower than the correlation between seriation and perceptual tasks, the ST can still predict basically non-perceptual academic task-achievement quite well because of the high component of reasoning in the academic tasks. The ST seems to transcend the perceptual-reasoning gap when predicting the academic abilities of second grade children.[152]

Seriation and Intelligence

Wallach, in his review of research of children's thinking, points out that the studies of the child's knowledge of his physical world rely on traditional concepts of thinking as reasoning, problem solving, and understanding (generally in a nonsocial world).[153] He

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[151] Ibid., p. 11.

[152] Nelson, op. cit., pp. 75-76.

[153] Wallach, op. cit., pp. 262-266.

notes the concurrence of evidence from factor analytic studies of children's performance and developmental studies that there is structural change in the nature of the child's adaptation to his universe between the age of 5 and 8. This is the period in which conservations of many properties across irrelevant changes appears and classificatory skills and seriating abilities become apparent.

Correlations between the subtests of Science-Research Associates Primary Mental Abilities Test and the Seriation Test on a sample of the population studied by Nelson are reported as being significant, ranging from .39 with Verbal Meaning to .77 with Number Facility; the PMA Total Score Correlated .75 with the Seriation Test.[154]

There is research evidence to substantiate the relatedness of seriating ability with other aptitudes and abilities. Welch and Long, for example, reported a study in which children were taught to identify simple geometric figures, then instructed to sort the figures. They found it easier for the child to identify three objects than to learn to identify the hierarchical structure of two objects and their class.[155] They also note that children who failed the hierarchy tests were inferior on a battery of supplementary tests; the two groups established on the basis of degree of success could be differentiated with a fair degree of reliability on the basis of the test battery. These conclusions were corroborated by significant correlations even

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[154] Nelson, op. cit., p. 63.

[155] L. Welch and L. Long, "The Higher Structural Phases of Concept Formation of Children", Journal of Psychology, 1940, 9 59-95.

when age was held constant.

In a somewhat different approach, Graham, et al., investigated the extent to which children could form concepts without verbal cues. Working with children aged 6 to 9, they established a response to "middleness", and tested for transfer of this concept to "middling" in density of white dots on black circles.[156] They found that all of the subjects who solved the discrimination problem had developed relevant verbal concepts.

Studies of transposition learning in animals and children indicate growth trends from absolute to relational basis of learning. For example, training for response to one of three boxes, differing only in size and presented in random arrangement on each trial, requires trial and error learning to discover which box contains the reward. Transposition learning is determined by discarding the smallest box and adding a larger one to determine whether choice will be absolute or relational. (Transposition, like seriation, may occur on stimulus dimensions other than size: pitch and intensity of auditory stimuli, etc.) Lower animals differ from humans in not showing transposition, and pre-school children differ in this regard from older children. The age period 5 to 7 is the point of transition for children from the associative to the cognitive level and is also claimed to be related to the ability to verbalize the relational

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[156] V. Graham, et al., "Generalization of the Concept of Middleness", Journal of Genetic Psychology, 1944, 65, 227-237.

choice.[157]

The research evidence seems to corroborate the relatedness of seriating to reasoning ability. According to Piaget and his associates, the ultimate development of operational seriation acts to develop decentrations and perceptual regulations, freeing perception from direct image interpretation and field dependency. This is described as an essential component in the evolution of logical thinking.

Implications for Training

As one part of his study, Nelson evaluated a training program in seriation by post-test on the Seriation Test. After only twelve thirty-minute training sessions there were differences between the experimental and control groups, although these were not statistically significant.[158] Research involving extended seriation training is necessary for further consideration of this issue.

To the extent that, as it appears possible, seriation may be stimulated and developed through training, an increase in general ability and aptitude should be associated with it. There are important implications in regard to some of the current issues in education in Nelson's report that in the lower socio-economic group "abilities often viewed as being a direct result of proper schooling were not too closely related to those abilities hypothesized as being related to the development of logical thinking".[159]

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[157] H. W. Stevenson and I. Iscoe, "Overtraining and Transposition in Children", Journal of Experimental Psychology, 1954, 47, 251-255.

[158] Nelson, op. cit., p. 86.

[159] Ibid., p. 67.

Scott proposes that compensatory education is significantly handicapped by starting with children past three years of age.[160] The importance of the child's earliest years has been emphasized by numerous authorities in psychology and education, implying the need for early and powerful intervention if remediation is to be effective. The verbal insufficiency frequently reported in the homes of the 'deprived' necessitates stimulation of free play in compensation. Scott suggests that this is possible by appeal to the child's intrinsic drive to learn through sensory and motor manipulation of objects.

This is substantiated by reports from divergent approaches to the problem. Hunt postulated free play as enabling the development of central processes.[161] Intensive and early intervention is implied in the data on the effects of environmental manipulations on rats by Rosenzweig et al.[162, 163]

The efficacy of intensified training is at issue for compensatory education program. There are optimistic reports from Deutsch[164]

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160 R. Scott, "Head Start Before Home Start", Merrill Palmer Quarterly, 1967, 13, 317-321.

161 J. McV. Hunt, Intelligence and Experience (The Ronald Press, New York, 1961).

162 M. R. Rosenzweig et al., "Variation in Environmental Complexity and Brain Measures", Journal of Comparative and Physiological Psychology, 1962, 55, 1092-1095.

163 M. R. Rosenzweig, "Environmental Complexity, Cerebral Change, and Behavior", American Psychologist, 1966, 21, 321-332.

164 M. Deutsch et al., The Disadvantaged Child (Basic Books, Inc., New York, 1967).

and from Bereiter and Engelmann[165] which provide stimulus for further analysis of the factors underlying successful interventions. Readiness programs stressing seriation give promise of being effective tools in the educational armamentarium.

RELATED SOCIO-CULTURAL VARIABLES

H. E. Jones effectively summarizes the problems in interpreting the research evidence:

> 1. The proportional contribution of heredity and environment does not refer to the makeup of individual IQs or to the general level of intelligence, but either to average effects upon individual differences or to differences between groups.
>
> 2. Existing studies are based on fallible and incomplete measures both of intelligence and of the environment; this fact should be remembered when the data are being manipulated to yield an apparently highly exact result.
>
> 3. Even if it is ever logically feasible to seek a single value for the effect of the environment, the particular value reported in a given study may not apply in samples involving
>
> (a) A different environmental level.
>
> (b) A different hereditary selection.
>
> (c) A change in variability of either of the above factors.
>
> (d) A change in any special condition which may effect the interaction of these factors.[166]

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[165] C. Bereiter and S. Engelmann, Teaching Disadvantaged Children in the Preschool (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1966).

[166] H. E. Jones, "The Environment and Mental Development" in L. Carmichael (ed.), op. cit., p. 633.

Whatever the problem in imputing causality, the literature abounds with reports of statistically significant correlates of IQ differences and changes. Among these are: basal metabolism, EEG pattern, height, weight, race, socio-economic status, father's occupation, anxiety level, parental intelligence and education, motivation, and a host of personality factors.[167, 168] 'Intelligent' behavior appears to be multiply determined and unidimensional studies of multidimensional problems yield dubious data.

Experimental Animal Psychology

The literature in experimental animal psychology indicates the necessity of specifying environmental conditions under which behavior is observed. Cooper and Zubeck reared groups of maze bright and maze dull rats, inbred for thirteen generations on this criterion.[169] Littermates were then raised in one of three experimental habitats: enriched, restricted, and natural. At 65 days of age, each of the six groups were tested. The enriched environment led to significant improvement for the dull rats, with no effect on the bright ones. The restricted environment resulted in dramatic impairment for the bright ones, and no appreciable differences for the dull animals.

Rosenzweig et al., reported increment in learning ability and

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[167] A. Anastasi, Differential Psychology (Macmillan Co., New York, 1958, 3rd ed.).

[168] L. Tyler, The Psychology of Human Differences (Appleton-Century-Crofts, New York, 1965, 3rd ed.).

[169] R. Cooper and J. Zubek, "Effects of Enriched and Restricted Early Environments on the Learning Ability of Bright and Dull Rats", Canadian Journal of Psychology, 1958, 12, 159-164.

performance in rats raised in enriched conditions and, even more, pathological findings on animals autopsied at 81 days of age.[170] (They reported increase in weight of cortex, increased size and weight of glial cells, and alteration of ratio of cholinesterase to acetyl cholinesterase.) Adverse findings were reported with thirty-three days in the deprived or restricted environment. However, reversing conditions for periods of six weeks produced findings on autopsy associated with the last condition.[171] The authors, however, give some indication that prolonging the restricted condition beyond two months may produce irreversible changes.

Freedman studied four breeds of dogs, each strain highly inbred, raising half of each litter under "indulgent" conditions and half "disciplined".[172] At two months of age, each pup was submitted to a series of tests for inhibition of eating after the person who had raised it punished it for eating and then left the room. Basenjis ate as soon as the trainer left the room, regardless of rearing conditions. All of the Shetland sheep dogs refused to eat over the testing period, regardless of rearing conditions. Among the Beagles and Fox terriers, however, the reaction was clearly related to rearing condition, with indulged pups being inhibited by the punishment. The complexities in

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[170] M. Rosenzweig, op. cit.

[171] D. Krech, et al., "Relations Between Brain Chemistry and Problem Solving among Rats Raised in Enriched and Impoverished Environments", Journal of Comparative and Physiological Psychology, 1962, 55, 801-807.

[172] D. Freedman, "Constitutional and Environmental Interactions in Rearing of Four Breeds of Dogs," Science, 1958, 127, 585-586.

the interaction of heredity and environment in behavior determination is suggested by this study and raises questions about the accuracy with which "independent variables" provide comprehensive description of the conditions of many studies.

Analogies to humans from these studies are not defensible, but tentative extrapolation in studies of a number of species may permit some applications which can be tested in humans to clarify clinical and naturalistic observation. Jensen notes that lower animals come more nearly equipped with systems for dealing with the conditions of their existence. He points out that:

> ...the higher the organism is in the phylogenetic scale, the less specific is its built-in program and the greater is the need for the individual to acquire adaptive programs through encounters with the environment, both physical and social. Thus, the developmental period in humans extends over more time than is needed for other animals to attain behavioral maturity, and the human's interaction with his social environment is a crucial factor in his psychological development.[173]

This suggests that deprivation may be even more deleterious for the human infant, but there may be more time to provide remediating interventions.

Socio-economic Conditions

Pasamanick and Knobloch studied the relationship between socio-economic level of the mother and complications of pregnancy and

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[173] A. R. Jensen, "Basic Processes in Intellectual Development" in M. Deutsch, I. Katz, and A. R. Jensen (Eds.), Social Class, Race, and Psychological Development (Holt, Rinehart and Winston, New York, 1968) p. 53.

paranatal difficulties in the child.[174] They reported a significantly higher incidence of spontaneous abortion and infant disability among the lower socio-economic groups. In speculating on the mediating variables, they suggested differences in nutritional conditions and medical care favored those in the higher socio-economic categories.

Cynthia Deutsch offers the hypothesis of interpenetration of the variables, rather than simply their interaction in the production of a particular trait as emphasizing processes which modify nature as well as nurture.[175] She notes that current findings in biology suggest that environmental factors influence the effects of genic determination. To the extent that this is valid, the findings relative to the effects of socio-economic factors and other pertinent cultural factors are confounded.

There have been a multitude of correlational studies of IQ and a host of specific socio-cultural factors. IQ has been studied in relation to parental occupation, income and education, among others.[176] Pintner cites data obtained on Gypsy and the Canal boat children, whose test scores decreased with age, as evidence of adverse "extrinsic factors".[177] Similar decrements in the rate of mental growth under

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[174] B. Pasamanick and H. Knobloch, "Epidemiological Studies on the Complications of Pregnancy and the Birth Process" in G. Caplan (Ed.), Prevention of Mental Disorders in Children (Basic Books, Inc., New York, 1961) pp. 74-94.

[175] C. Deutsch, "Environment and Perception", in Deutsch, Katz, and Jensen, op. cit., p. 61.

[176] Pintner, op. cit., 513-519.

[177] Ibid., pp. 94-97.

extremely unfavorable conditions have been observed among the children of Appalachia, in replicated studies.[178]

The limitations in such data are apparent in the debates that ensued as to the relative contributions of heredity and environment to intelligence. The significance of correlation coefficients in the order of .40 to .45 for IQ and socio-cultural variables was weighed against correlations of .50 to .55 for IQ of parent and offspring.[179] Contemporary researchers are more sophisticated. Recognizing the impossibility of separating out effects which have been "interpenetrated" and compounded, current studies take a different approach to the problem.

Sitkei reported an application of Guilford's structure of intellect theory in a comparative study of middle and lower class four year olds of two ethnic groups.[180] He reported that middle class excelled lower class children in all abilities in both ethnic groups; the class differences were greater on the "verbal cognitive-convergent factor"; the superiority of the whites was sustained only on the verbal comprehension factor; lower class Negroes were relatively more behind middle class Negroes on the verbal cognitive convergent factor than

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[178] L. R. Wheeler, "A Comparative Study of the Intelligence of East Tennessee Mountain Children", Journal of Educational Psychology, 1942, 33, 321-334.

[179] Pintner, op. cit., pp. 504-525.

[180] E. G. Sitkei, Comparative Structure of Intellect in Middle and Lower Class Four Year Old Children of Two Ethnic Groups (Doctoral Dissertation, 1966, University of Southern California - 1967 Dissertation Abstracts).

were white lower class children when compared with white middle class.

Rapier hypothesized on the basis of Jensen's work that (1) IQ is a better predictor of serial learning for high SES subjects than for low SES; (2) Paired associate learning (related to verbal mediation) is correlated with IQ; and (3) Mediation instruction is more effective for low SES than high SES subjects in improving paired associate learning.[181] She concluded that her data corroborated Jensen's reports that the differences in learning ability on the serial and paired associate learning tasks may be effective in differentiating the organically retarded from the academically limited students with an early history of deprivation. Further, her findings confirmed the concept that the IQ is a better predictor of learning ability for those of high SES.

Whiteman and Deutsch reported a comparative study of first and fifth graders in New York City schools, which differentiated socio-economic status and race.[182] They found a significant deficit on the basis of socio-economic status. They noted that the SES deficit was manifested earlier than that for race, and was equally pronounced at both grade levels.

The child living in the slums has been described by Whiteman and Deutsch as having less interaction with his parents and being more

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[181] J. Rapier, The Learning Abilities of Normal and Retarded Children as a Function of Social Class (Unpublished Doctoral Dissertation, 1966, University of California, Berkeley, California).

[182] M. Whiteman and M. Deutsch, "Social Disadvantage as Related to Intellective and Language Development", in Deutsch, Katz, and Jensen (Eds.), op. cit., pp. 86-114.

likely to live in crowded, cluttered, noisy surroundings, with less of a variety of things to stimulate him in the direction expected by the schools.[183] Recent investigations of the relationship between perceptual factors and social class substantiate effects of such conditions.

Covington found that there was a significant initial deficiency in a discrimination task of abstract visual stimuli in lower SES children.[184] In a controlled experiment, he reported that familiarization with abstract visual material (fourteen daily exposures to thirty slides) resulted in greater gains for the lower class subjects than for the upper class experimental group. But both groups improved as compared with controls on post-test on the Perceptual discrimination subtest of Thurstone's Test of Primary Mental Abilities. Covington suggests that the initial deficiency of the lower class children is more a lack of verbal labels, and that experimental exposure permitted organization and labeling of the kind which is usually available to children in families of the higher SES groups.

In another approach, Zigler and de Labry used a variety of reinforcers with retarded and normal children, differentiated by social class.[185] They reported that mentally retarded and lower class

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[183] Ibid.

[184] M. V. Covington, "Stimulus Discrimination as a Function of Social Class Membership", Child Development, 1967, 38, 607-613.

[185] E. Zigler and J. de Labry, "Concept Switching in Middle Class, Lower Class and Retarded Children", Journal of Abnormal and Social Psychology, 1962, 65, 267-273.

children learned more effectively with tangible rewards, while middle class children responded to intangible social reinforcement. They found no differences in concept switching ability when each group received the optimal reinforcer.

One of the most significant reports relating mental growth and environmental situation was that of Wheeler.[186] A cross sectional study of children, aged 6 to 16, showed a twenty point decrease in IQ score over this age range (from an average of 94.7 to 73.5). In 1940, ten years after the original study, Wheeler repeated this work, finding a similar decrease at a higher level (from 102.6 at age 6, to 80 at age 16). He related the failure of these children to make the normal amount of growth to the effects of poverty, social isolation, irregular school attendance, and the absence of a demanding, challenging environment.

Ethnic Factors

The immigrant influx coincided with the development of the testing movement in the United States and provided for a mass of comparative studies of people of different national origin. Pintner cites studies showing the English, Scotch, and Jews are slightly above average, Germans, Swedish, and Norwegians average, with Finns slightly lower, followed by Italians, Polish, and Portugese respectively.[187] A number of studies reported on Mexican children in the U.S. produced mean IQ scores from 78 to 96.[188] (It is not specified whether or not

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[186] L. R. Wheeler, op. cit.

[187] Pintner, op. cit., p. 456

[188] Ibid., p. 452.

these children were born and/or educated in the U.S.) Similarly, American Indians scored in the 70 to 92 range.[189]

This data has been questioned, however, and is open to other interpretation.[190, 191] The need for translation of tests or use of interpreters is a major deviation from standardization procedure. Factors such as ethnic origin of the examiner, and his emotional warmth and expectations might have influenced these results. Questions about the representativeness of the immigrant samples have been raised and information on socio-economic status and educational background is not generally reported.

The most extensive comparisons of two ethnic groups have been with reference to Negroes and whites in this country. The average IQ in Negro groups has been reported generally as 85 to 90.[192] There is an abundance of evidence that these scores are below that of the White comparison groups. But the point is made that 30% of the Negroes exceed the mean score of the Whites, making individual prediction on the basis of group norms untenable.[193] Further, Klineberg cited two different studies, one in Los Angeles and one in rural Virginia, where the IQ of the Negro groups was approximately 10 points below that of

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[189] Ibid., p. 451.

[190] A. Anastasi, Differential Psychology (Macmillan Co., New York, 1958, 3rd ed.) pp. 542-603.

[191] O. Klineberg, Race and Psychology (UNESCO, 1951).

[192] O. Klineberg, "Negro-White Differences in Intelligence Test Performance", American Psychologist, 1963, 18, 198-203.

[193] Ibid., p. 201.

the Whites. However, the differences between the Negroes with average IQ score of 95 in Los Angeles and 76 in Virginia, were greater than the Negro-White differences in either instance.

The significance of individual differences was highlighted by the Witty and Jenkins study concerning the degree of white ancestry in Negro school children with IQ above 125. Their findings substantiated that the proportion of white ancestry in the superior children was not greater than among the Negro population in general.[194] Herskovits reported the same findings earlier.[195]

Klineberg's classical studies on regional differences and educational opportunity related to IQ scores among Negroes have pointed out some of the methodological problems, as well as the substantive data reported.[196] It appears that each individual is actually a member of several groups, some of which may be overlapping. Cross-racial and cross-cultural type studies which take into account a multiplicity of factors in the environment which are known to be related to intellectual growth are essential. Further, Klineberg questions the adequacy with which motivation, interest, operation of social expectancy, and examiner-testee relationship have been assessed.[197, 198]

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[194] P. A. Witty and M. D. Jenkins, "Intra-race Testing and Negro Intelligence", Journal of Psychology, 1936, 1, 179-192.

[195] M. J. Herskovits, "On the Relation Between Negro-White Mixture and Standing in Intelligence Tests, Journal of Genetic Psychology, 1926, 33, 30-42.

[196] O. Klineberg, Race Differences, Harper, New York, 1935.

[197] Ibid.

[198] Klineberg, op. cit.

The study by Whiteman and Deutsch utilized the same subjects, reclassified with reference to different criteria, in an analysis of variance design in order to identify significant effects of each of the factors, as well as the interaction between them.[199] They concluded that the decrement associated with race begins later than that associated with SES and is cumulative, being far more pronounced in older children. They reported that, in fact, it was compounded by adverse socio-economic status as well.

Furthermore, and not the least of the many problems confronting investigators in this area, is the question of defining and assigning racial group membership. Human races are defined in terms of the relative frequency of certain genes, as "breeding populations which change as gene frequencies change."[200] In spite of the fact that Negro American gene pools are estimated to contain twenty-five percent white genes, the popular definition of a Negro is sociocultural, based on skin color.[201] Individuals with one Negro grandparent (seventy-five percent white gene pool) are classified as Negro.

There seems to be a concurrence among authorities that investigations purporting to deal with "race differences" are riddled with the total of these ambiguities. The demonstration of "race differences' in comparisons of various ethnic groups does not demonstrate differences

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[199] Whiteman and Deutsch, op. cit., pp. 103-104.

[200] I. I. Gottesman, "Biogenetics of Race and Class" in Deutsch, et al (Eds.) op. cit., pp. 11-51.

[201] Ibid., p. 15.

resulting from race. The fact that the ethnic minority groups also differ in other aspects of culture and environment from the dominant White majority in our society complicates any attempt at interpretation of the most carefully observed and documented differences in behavior.[202]

The Nature of Deprivation

Studies on the nature of deprivation are confounded by multi-barreled questions and multiply determined effects.[203] While it is clear that limited and marginal economic conditions impose hardships on the family, effects on the children are not sufficiently homogeneous for this concept to be equated with deprivation. It has been clearly demonstrated that the association of minority ethnic status and poverty are compounded in their deleterious effects on the child.

The Kerner report uses the Social Security Administration definition of poverty (annual income of $3335.00 for urban family of four) to show that thirty million people, or fifteen percent of the population lives below the poverty level.[204] The poor are overwhelmingly white--over twenty million versus less than ten million nonwhites. These figures, however, indicate that less than twelve percent of the Whites are 'poor', while over forty percent of the nonwhites are included in this category.[205] While this formulation provides a definition of poverty, it avoids the questions implicit in the concept of deprivation.

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202 Anastasi, op. cit., pp. 542-570.

203 cf. supra. pp. 56, et seqq.

204 O. Kerner, Chairman, Report of the National Advisory Commision on Civil Disorders (Bantam Books, New York, 1968) p. 58.

205 Ibid., p. 59.

Whiteman and Deutsch propose that two conditions must be met for environmental factors to be viewed as reflecting social deprivation: (a) such factors must be associated with social grouping like race or class, and (b) they must be related to some actual decrement in performance.[206] The significance of the child's family relationships to his personality development has been widely studied as they mold self-concept and ability to relate to other people. These factors, in turn, are related to intellectual efficiency and performance by substantial research evidence.[207]

Whiteman and Deutsch derived a "Deprivation Index" which takes into account something of the nature of the interpersonal relationships in the family. Even more, this allows for the cumulative effects of multiple adverse factors in the child's environment.[208] This index is based on consideration of education and occupation of parents, housing condition, motivational aspects in parents, etc. They reported this index was found to be significantly related to both low SES and poor school performance. Its value was further demonstrated in the finding that it differentiated in groups homogeneous for SES and race on the dimension of academic achievement.

The effects of sensory deprivation, lack of intellectual stimulation, social and cultural alienation, and absence of significant interpersonal relationships seems to be best summarized in the

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[206] Whiteman and Deutsch, op. cit., p. 91.

[207] I. G. Sarason, Personality: An Objective Approach (John Wiley and Sons, New York, 1966) pp. 377 et seqq.

[208] Whiteman and Deutsch, op. cit., p. 100.

statement by Bruner:

> Not only does early deprivation rob the organism of the opportunity of constructing models of the environment, it also prevents the development of efficient strategies for evaluating information--for finding out what leads to what and with what liklihood. Robbed of development in this sphere, it becomes the more difficult to utilize probable rather than certain cues, the former requiring a more efficient strategy than the latter. Then there is the matter of the unsuccessful attempt to order the unorderable environment perceptually.[209]

SUMMARY

The major contributions to the understanding of the nature of intelligence have come from three major approaches to the study of the problem: (1) the psychometric tradition which has resulted in definition by accretions of test ideas and attributes including reasoning, judgment, adaptability, memory, etc.; (2) experimental and statistical studies which postulate the existence of multiple abilities, impugning the global, unitary concept of intelligence; and (3) mental growth studies which have focused on content (as in the age normative data) and process (as in developmental studies, particularly the genetic epistemology of Piaget).

Nancy Bayley effectively summarizes the present state of knowledge:

> Intellectual growth of any given child is a resultant of varied and complex factors. These will include his inherent capacities for growth, both in amount and in rate of progress. They will include the emotional climate in which he grows;

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[209] J. S. Bruner, "The Cognitive Consequences of Early Deprivation", in P. Solomon, et al., (Eds.), Sensory Deprivation (Harvard University Press, Cambridge, Mass., 1961) p. 202.

> whether he is encouraged or discouraged, whether his drive (ego involvement) is strong in intellectual thought processes or is directed toward other aspects of his life field. And they will include the material environment in which he grows; the opportunities for experience and for learning, the extent to which these opportunities are continuously geared to his capacity to respond and to make use of them.[210]

Perceptual development has been traditionally studied in isolation, as an independent and parallel process to mental growth. But current research indicates that there is, at least, reciprocal action between perception and the evolution of intellectual activity. Whether perception may be viewed as one dimension on the continuum of the development of mental growth or as a level in a hierarchic organization of mental activity remains to be determined. But these are among the ways in which perceptual activity has been related to cognition by theorists. Bruner conceptualizes the perceptual process as an act of categorization. Current training programs, such as those proposed by Frostig and Kephart, assume a unidimensional development from perception to cognition.

There are diagnostic implications of perceptual handicaps which confirm that perception is related to cognition. Impairment in intellectual function is associated with particular patterns of perceptual disturbance and distortion which are also useful in differentiating between "brain damaged" and "undifferentiated" mentally retarded.

Seriation, (the process of ordering), which parallels classification, (the process of grouping) and merges with it to provide the

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[210] N. Bayley, "On the growth of Intelligence", American Psychologist, 1955, 10, 807.

basis for the development of logical thinking, seems to constitute a link between perceptual and cognitive activity. A serial configuration constitutes a good perceptual form, according to Piaget, at the simplest level. However, associated with ability for representation and anticipation, seriation becomes operational, i.e., transitivity and reversibility are manifest. Nelson's claim that the Seriation Test transcends the perceptual-reasoning gap in predicting academic ability further implies the usefulness of this operation in the understanding of mental growth.

The attempts which have been made to specify the environmental universe in terms of sociocultural variables related to mental growth and child development have generally formulated single answers to what should have been multi-barreled questions. Contemporary research indicates an ever increasing fusion of psychology and biology. The evidence in regard to mental growth is that social psychology and biochemistry flow together. In fact, the pertinent variables are not found in isolation.

Factors relative to socio-economic condition, minority ethnic status, and cultural deprivation such as are associated with impaired learning ability in school are further confounded by the nature of the interpersonal relationships in the family and personality development. Yet, the need to specify the environmental universe is imperative in order to provide the background of understanding which is essential if there are to be effective and remediative interventions.

CHAPTER III

DESIGN OF THE STUDY

The problems and theoretical assumptions underlying the study have been reviewed in Chapters I and II. The study proposed in the initial chapters provides for an analytic investigation of seriation and perception in the structure and function of intellectual and academic performance among the group identified as Educable Mentally Retarded. The following Sections describe the population, procedures for assessment, and the methods of statistical analysis employed in the study.

SELECTION OF THE POPULATION

The target population consisted of 284 students enrolled in the spring semester, 1969, in the elementary schools in Stockton Unified School District, who had been certified as Educable Mentally Retarded. This school district covers an area largely urban, although the outlying agricultural region provides a substantial amount of employment for residents in seasonal farm labor. The wide socio-economic range of the residents and heterogeneity of ethnic background is reflected in the 1960 census tract data.[211] Table I presents a comparison of the ethnic composition of the general elementary school population with that in the special classes.

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[211] U.S. Bureau of the Census. U.S. Census of Population and Housing: 1960, Census Tracts. Final Report PHC (1)-153. U.S. Government Printing Office, Washington: 1962.

TABLE I

COMPARISON OF ETHNIC COMPOSITION OF STUDENTS IN SPECIAL AND GENERAL ELEMENTARY CLASSES IN STOCKTON UNIFIED SCHOOL DISTRICT[212]

	Spanish Surname	Other White	Negro	Chinese-Japanese	Other Non-White	Total
Special	82 (28.8%)	87 (30.9%)	103 (39.4%)	3 (.011%)	9 (3%)	284
General	3627 (19.4%)	11018 (59.0%)	2701 (14.5%)	727 (3.9%)	590 (3.1%)	18663

The median family income in each of the thrity-two elementary schools in the district, as reported in the 1960 Census Tract Data, ranges from a low of $3345. per year to a high of $7969. The San Joaquin County Department of Public Assistance in the monthly report for May, 1969, (available on request) reported 2432 children (13%) in the Stockton elementary schools were supported by funds from the program for Aid to Families with Dependent Children. Among the children in these special classes, 94 (33.1%) are supported from these funds. It is readily apparent that this population either in distribution of socio-economic level or ethnic composition.

Teacher evaluation of student socio-economic status was obtained on a two factor rating scale[213] based on conditions of occupation and

[212] Data on general students from District Report, October 1967; on EMR classes, by teacher report, March 1969.

[213] This was part of the rating scale used by Nelson, op. cit.

home. (Appendix A.) The lower class sample consists of those from families of unskilled workers and/or those supported by public funds and also living in poor or very poor housing, as described in the scale. The middle class sample was defined as those from families of semi-skilled, skilled, or white collar workers who live in fair or better housing. Ethnic background was also indicated by teacher for each student in the class, on the basis of home visits as well as classroom knowledge of the child. Oriental students and those of mixed or uncertain parentage were excluded.

Of the total EMR population, there remained 110 pupils, between the ages of 8-6 and 13-3 (median age 10-9) who met the criteria for inclusion in the ethnic and socio-economic groups, as follows:

11 white, middle class boys
10 white, middle class girls
7 white, lower class boys
8 white, lower class girls
6 Mexican-American, middle class boys
2 Mexican-American, middle class girls
11 Mexican-American, lower class boys
18 Mexican-American, lower class girls
4 Negro, middle class boys
1 Negro, middle class girl
12 Negro, lower class boys
20 Negro, lower class girls

There were insufficient numbers of middle class pupils from the ethnic minority groups to constitute groups for the purpose of statistical analysis. In order to establish groups of equal number to facilitate analysis, a table of random numbers was used to select subjects for this tudy. The analysis, as presented, is based on data obtained on 74 students: ten boys and ten girls of each the Mexican-American and Negro lower class and white middle class. The white lower

class groups were of necessity limited to seven boys and seven girls.

SELECTION OF INDEPENDENT VARIABLES

In the review of the literature, it was noted that studies attempting to specify the environmental universe in which the child develops have tended to deal with single aspects of the soicocultural milieu while, in fact, the pertinent variables do not exist in isolation. Nonetheless, the rigors of scientific method and statistical analysis impose limitations on studies. The lack of clear definition for 'cultural deprivation' and the dubious methods for determining the nature of interpersonal relationships in the family constitute further obstacles. The relative ease and agreement with which socio-economic level and ethnic group membership may be rated render these dimensions amenable to investigation.

The use of socio-economic level and ethnic group as independent variables in this study was designed to measure these effects independently and in interaction with other dimensions related to school progress. Mental ability, perception, and seriation are developmental constructs in that they have been demonstrated to increase with age. In combination with socio-economic and ethnic factors, in the factorial analysis of variance procedure, it was possible to test experiential background variables in terms of their interaction or mutual interplay with the developmental constructs. Academic achievement, age, and sex as control factors, paired with socio-economic and ethnic data, yield

similar information.

Since, specifically, this study is addressed to providing a descriptive analysis of seriation, Seriation Test scores were used as the dependent variable through all of the analysis of variance studies reported in the next chapter. Helmstadter's concept of construct validity is particularly relevant to issues in clinical assessment.[214] An understanding of the underlying theoretical constructs is a requisite for confidence in clinical conclusions and recommendations.

DATA GATHERING PROCEDURES

The data analyzed in this study are the products of measures of intelligence, visual-motor integration, conception of space, perception, academic achievement, and seriating ability as described in the following sections. District policy requires re-evaluation of each student in the EMR program every three years. Such re-evaluations were scheduled for the elementary school level in Stockton Unified School District in February and March, 1969. All of the procedures used for gathering the data were administered during this period. Students were, accordingly, familiar with examination procedures and accepting of these methods with no implication of being singled out for any special reason.

Measure of Intelligence

Each pupil certified for the EMR program is required by state

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[214] Helmstadter, op. cit.

law to be evaluated on an individually administered test of intelligence.[215] The results of such tests given within the past three years or those from the current evaluation were available for this study. Information used was based on the Wechsler Intelligence Scale for Children[216] or the Stanford-Binet, Form L-M.[217] These tests have been demonstrated to have the highest predictive validity in the school situation and have also been highly correlated with each other.[218] The scores on these tests, expressed as Intelligence Quotients, were used as the measures of intelligence in this study.

Measure of Visual-Motor Integration

The eighteen figures used by Piaget[219] in his studies of the child's development of conception of space were reproduced to yield developmental levels on the dimension of reproducibility of figures. (Appendix B.) The several studies establishing age norms for copying common figures (line, perpendicular cross, oblique cross, circle, square, triangle, and diamond) have been compiled in a recent manual which served as the scoring standard.[220]

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[215] Education Code, Vol. 1, Section 6902.05, p. 394. State of California, Department of General Services Documents Section Sacramento: 1968.

[216] Wechsler Intelligence Scale for Children, Psychological Corporation, New York, 1949.

[217] Stanford-Binet, Form L-M, Houghton Mifflin Co., New York, 1960.

[218] A. Anastasi, Psychological Testing, MacMillan Co., New York, 1954, p. 319.

[219] J. Piaget and B. Inhelder, The Child's Conception of Space, (Routledge and Kegan Paul, London, 1956) p. 58.

[220] Berry, op. cit.

This device was administered in the classroom to groups of eight students at a time, with instructions to draw each design in the empty box just below it. This task was not timed; it was generally completed in approximately ten minutes.

Conception of Space

The same set of figures which yielded scores in terms of the developmental level at which the child could copy figures (Appendix C.), also permitted evaluation in Piagetian terms of the development of the conception of space. These are rated according to stages by Piaget:[221]

Substage IA - to age 3, differentiated scribbling.

Substage IB - 3 to 4 years old, figures generally reproduced as closed curves, topological relationships indicated with some accuracy.

Substage IIA - beginning at age 4, shapes distinguished according to their angles and dimensions, points of contact or intersection not properly represented.

Substage IIB - (age not specified) rhombus and circumscribed figures (except 16) are gradually mastered.

Stage III - 6 to 7 years of age, all of the problems are overcome, including the complex composite figure. (This is the stage of Euclidean awareness).

If, as Piaget argues, each phase of development is necessary for the emergence of subsequent, more mature stages, there should be relevance for educational planning if it is substantiated that young children are capable only of seeing, depicting, and executing topological features and patterns. There might be some value in establishing a correspondence of formal academic instruction with the age at which the child makes the critical transition from topological to Euclidean awareness and capacity.

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[220] Piaget and Inhelder, op. cit., pp. 52-79

Measure of Perception

Eighteen of the simpler Gottschaldt figures[222] were selected and reproduced for test administration immediately following the copying of designs. (Appendix B.) Thurstone reported that finding the hidden figures on this procedure yielded principal saturation on factors concerned with the strength of perceptual configuration, rate of alternation in ambiguous configurations, and the manipulation of two figures simultaneously or in succession.[223] Tracing the hidden figures also requires the subject to make an overt motor response. However, since the precision with which the figures are indicated is irrelevant and scoring is concerned with the subject's ability to discern the smaller designs in the larger, more complex design, this appears to be more "perceptual" than the visual-motor integration required for copying.

The Gottschaldt figures, hereafter referred to as the Hidden Figures Test, was distributed to the group after the copied designs had been collected. The four boxes at the top of the page were reproduced on the blackboard and completed by the examiner as examples of the procedure. Following this instruction, the students were told that in each of the other boxes, the first figure was hidden in the second, larger design. They were told to find it by themselves and mark the hidden figure with pencil as had been demonstrated on the board. There was no further assistance given. This task was not timed; it generally required about fifteen minutes for completion.

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[222] Thurstone, op. cit., p. 73.

[223] Ibid., pp. 89-124.

Measure of Academic Achievement

The Wide Range Achievement Test, Level 1,[224] was administered individually to each student, and scored according to the Manual. This test yields grade level scores on reading (word recognition and pronunciation), written spelling, and arithmetic computation. In the treatment of the data, the reading and spelling scores were averaged for each pupil to obtain a more stable estimate of achievement level in the composite score.

Measure of Seriating Ability

The Learning Readiness System Seriation Test[225] (preschool level) was administered in an independent session to students in groups of four to six. This test presents the child with twenty-four tasks in which visual patterns have to be ordered according to size. This is accomplished by matching and pasting related figures, marking pairs with pencil, and circling the item which matches the original stimulus pattern. There is no time factor; the complete test takes about forty-five minutes.

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[224] Wide Range Achievement Test, Guidance Associates, Wilmington, Delaware, 1965.

[225] The Learning Readiness System Seriation Test, Harper and Row, Inc., New York, 1968.

METHODS OF STATISTICAL ANALYSIS

The scores obtained on the dimensions of intelligence, visual-motor integration, perception, academic achievement, and seriation for the seventy-four students selected as described in the preceding sections of this report were subjected to statistical analysis. Non-parametric confirmation of the distribution of scores was obtained to validate the use of these scores in the statistical procedures discussed in the following sections of this report.

Analysis of Variance

The major statistical test used through this study was a two-way analysis of variance in a 2 X 2 factorial design. This method provides for examining statistically the differences in seriating ability in relation to a number of independent variables, such as socio-economic level, ethnic background, intelligence, achievement, perceptual development, and visual-motor integration. In this procedure for factorial analysis of variance, the differences of two (or more) groups are tested for statistical significance by analyzing the independent and interactive effects of two (or more) variables on a dependent variable.

The advantages of this approach are summarized by Kerlinger who says, "Factorial analysis of variance and other multivariate notions, as well as the research designs they imply...make it possible to expand greatly our conceptions and our methods of research and analysis."[226]

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[226] F. N. Kerlinger, Foundations of Behavioral Research, (Holt, Rinehart and Winston, Inc., New York, 1965) p. 214.

Such analysis yields conclusions beyond the usual statement of differences between effects or groups by indicating the differential effect of the variables under investigation by dealing with variances within and between groups. From the standpoint of methodology, analysis of variance is especially well suited to research designs in which the same subjects are reclassified with reference to different criteria, as done in this study.[227]

Ten analyses of the independent and interactive effects of the following pairs of independent variables on the seriation test scores of this population were computed: socio-economic status by achievement, socio-economic status by intelligence, intelligence by ethnic group, intelligence by perception, perception by ethnic group, achievement by ethnic group, perception by sex, intelligence by sex, ethnic group by age, and IQ by age.

On the basis of theory or prior observations a difference might be expected, but statistical testing required propositions in the form of the following null hypotheses:

1. There are no significant differences in seriating ability between children from lower and middle class homes.
2. There are no significant differences in seriating ability between children of borderline mental ability and those who are more retarded.
3. There are no significant differences in seriating ability between those of poorer and better perceptual ability.
4. There are no significant differences in seriating ability between children of higher and lower academic level.
5. There are no significant differences in seriating ability among those from different ethnic groups.
6. There are no significant differences in seriating ability between boys and girls.

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[227] Ibid.

7. There are no significant differences in seriating ability between older and younger children.

Furthermore, in the factorial design it was possible to test for the interactive effects of each pair of variables. That is, the mutual interplay between each of the pairs of variables provided as 'interaction term' which was tested simultaneously.

If observed differences were statistically significant, the data was regarded as supporting the research hypotheses. The appropriate tables were used to indicate the probability of random differences. For p between .05 and .01, the differences was regarded as significant, the null hypothesis as questionable; for p less than .01, the null hypothesis rejected.

Since this was not an experimental study in which the independent variables were manipulated and, consequently, the numbers in each group could not be controlled, the scores categorized on two dimensions simultaneously resulted in unequal numbers in the cells. Accordingly, the unequal cells frequency method, suggested by Edwards,[228] was used to yield an estimate of analysis of variance.

Correlational Analysis

Simple linear correlation was the statistical technique used to describe the strength of relationship between the factors which constituted the independent variables in this study. While the analysis of variance procedure works with the relation between the independent and dependent variable, the relationship itself may only be inferred

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[228]A. L. Edwards, Experimental Design in Psychological Research, (3rd ed. Holt, Rinehart and Winston, Inc., New York, 1968) pp. 264-267.

from significant differences (if any are indicated by the F test) without suggestion as to the degree of the relationship. Pearson product moment correlation coefficients provided this information. They were computed as a direct statement of the relationship between the variables under consideration in this study.

Another form of correlational analysis which may be productively applied to multivariate data is that of partial correlation. This method, according to Ferguson, "deals with the residual relationship between two variables where the common influence of one or more variables has been removed".[229] In the statistical elimination of the effect of a third variable, the efficiency of prediction is maximized.

For example, it might reasonably have been assumed that both seriation and arithmetic would show an increase with age. Such relationship was confirmed by the computation of the correlation coefficient which indicated statistically significant relationships for both seriation and age and arithmetic and age. It was possible then that scores on the seriation test and arithmetic test might have been correlated with each other because of their mutual association with age. The statistical elimination of the effects of the third variable was accomplished by the computation of the partial correlation coefficient.

The results of the study as presented in Chapter IV, therefore, included correlations of seriation and perception with intelligence partialled out, seriation and perception with age partialled out, perception and reading with age partialled out, perception and reading

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[229] G. A. Ferguson, Statistical Analysis in Psychology and Education, (McGraw Hill Book Company, Inc., New York, 1959) p. 290.

with intelligence partialled out, seriation and arithmetic with intelligence partialled out, seriation and reading with intelligence partialled out, seriation and reading with age partialled out and seriation and arithmetic with age partialled out.

Because of the fact that scores on the tests for visual-motor integration and conception of space were not amenable to the more elaborate forms of analysis, Chi-square (which is suitable for categorical data) was computed to arrive at an estimate of the significance of these dimensions in the intellectual functioning of this group.

SUMMARY

This Chapter has outlined the design and methods of this study. The demographic data for the school district has been compared with that for the population in the EMR program on the salient characteristics of socio-economic level and ethnic composition. The selection of the population of 74 EMR students, aged 8-6 to 13-3 was specified. The data gathering procedures for the assessment of intelligence, perception, visual-motor integration, conception of space, academic achievement, and seriation were described.

The use of non-parametric techniques to confirm the distribution assumptions in analysis of variance were described. The data which were not amenable to analysis in that way were used in contingency tables and Chi-square computed to estimate their significance.

The major statistical technique used in this study was analysis of variance in 2 X 2 factorial design. This method is particularly well adapted for designs in which the same subjects are reclassified

with respect to different criteria. The additional advantages of correlational analysis in describing the data by direct expression of the degree of relationship between the variables under consideration and the partial correlation coefficient which provides for the statistical elimination of the effects of a third variable were discussed.

CHAPTER IV

PRESENTATION AND ANALYSIS OF RESULTS

The study, as proposed in the initial chapter of this report, required several stages of data collection as described in Chapter III. The results obtained through statistical analysis of the data gathered are presented in this chapter.

The distribution of test scores on each of the measurement instruments provided non-parametric confirmation of normalcy, meeting the assumption underlying analysis of variance. For the data which did not meet this criterion, the Chi-square method served as an estimate of the statistical significance of the data. The results are further described by correlational analysis and computation of partial correlational coefficients. The major portion of this Chapter consists in the presentation of the data for ten factorial analysis of variance studies.

DISTRIBUTION OF TEST SCORES

A preliminary analysis of the obtained test scores was indicated to ascertain the nature of the distribution of scores in order to determine whether the assumption of normal distribution for the factors used in analysis of variance procedures were being met. Total scores were computed and the quartile points for that score distribution were calculated from the group's mean and standard deviation for each of the measures used. Test scores were then tallied in the appropriate quartile range, and the obtained frequencies were compared to those expected in a normal distribution. This procedure permitted nonparametric confirmation of the validity of the assumption underlying the major

statistical technique used in this study.

On the basis of these findings, the statistical proposition of the null hypothesis for the differences between the observed frequencies and those expected was confirmed for the distribution of scores on the intelligence test, seriation test, arithmetic, and perceptual ability measures. That is, for these four score distributions, the quartile frequencies as verified by Chi-square did not differ from that expected under the normal curve any more than might be obtained by chance. In the case of the reading test scores, the differences were at the level where this might have occurred by chance less than five times in a hundred. The skewed distribution of the scores on the test for Visual Motor Integration might have been obtained less than two times in a hundred by chance. In view of the fact that scores on the reading test and copying designs failed to conform to frequency distribution expected under the normal curve, these measures were not used in the analysis of variance procedures. The ratings on the child's Conception of Space yielded categorical data, also not amenable for analysis of variance.

The Chi-square comparisons for the observed and expected frequencies of scores on each of the measures described in Chapter III, and obtained in the initial stages of this study, are presented in Tables 2 through 7.

TABLE 2

DISTRIBUTION OF INTELLIGENCE TEST SCORES (IQ)

	Observed	Expected	O-E	$(O-E)^2/E$
Above $\bar{X}$ + .675 s. d. (IQ 78 and above)	13	18.5	5.5	1.63
$\bar{X}$ to ($\bar{X}$ + .675 s. d.) (IQ 72 - 77)	23	18.5	4.5	1.09
$\bar{X}$ to ($\bar{X}$ - .675 s. d.) (IQ 65 to 71)	23	18.5	4.5	1.09
Below $\bar{X}$ - .675 s. d. (IQ 64 and below)	15	18.5	3.5	.66
		Chi-Square= 4.47*		

*Not significant; d. f. = 3.

TABLE 3

DISTRIBUTION OF SERIATION TEST SCORES

	Observed	Expected	O-E	$(O-E)^2/E$
Above $\bar{X}$ + .675 s. d. (92 and over)	23	18.5	4.5	1.09
$\bar{X}$ to ($\bar{X}$ + .675 s. d.) (74 - 91)	22	18.5	3.5	.66
$\bar{X}$ to ($\bar{X}$ - .675 s. d.) (55 - 73)	13	18.5	5.5	1.63
Below $\bar{X}$ - .675 s. d. (54 and below)	16	18.5	2.5	.34
		Chi-square = 3.72*		

*Not significant; d. f. = 3.

TABLE 4

DISTRIBUTION OF HIDDEN FIGURES TEST SCORES

	Observed	Expected	O-E	$(O-E)^2/E$
Above $\bar{X}$ + .675 s. d. (Score 14 and over)	22	18.5	3.5	.66
$\bar{X}$ to ($\bar{X}$ + .675 s. d.) (Score 8.6 to 13)	18	18.5	.5	.01
$\bar{X}$ to ($\bar{X}$ - .675 s. d.) (Score 5 - 8.5)	12	18.5	6.5	2.28
Below $\bar{X}$ - .675 s. d. (Score 4 and below)	22	18.5	3.5	.66
		Chi-square = 3.61*		

*Not significant; d. f. = 3.

TABLE 5

DISTRIBUTION OF ARITHMETIC TEST SCORES

	Observed	Expected	O-E	$(O-E)^2/E$
Above $\bar{X}$ + .675 s. d. (Grade 2.9 and over)	14	18.5	4.5	1.09
$\bar{X}$ to ($\bar{X}$ + .675 s. d.) (Grade 2.1 to 2.8)	26	18.5	7.5	3.04
$\bar{X}$ to ($\bar{X}$ - .675 s. d.) (Grade 1.4 to 2.0)	15	18.5	5.5	1.63
Below $\bar{X}$ - .675 s. d. (Grade 1.3 and below)	19	18.5	.5	.01
		Chi-square = 5.77*		

*Not significant; d. f. = 3.

TABLE 6

DISTRIBUTION OF READING TEST SCORES

	Observed	Expected	O-E	$(O-E)^2/E$
Above $\bar{X}$ + .675 s. d. (Grade 2.4 and above)	13	18.5	5.5	1.63
$\bar{X}$ to ($\bar{X}$ + .675 s. d.) (Grade 1.7 to 2.3)	23	18.5	4.5	1.09
$\bar{X}$ to ($\bar{X}$ - .675 s. d.) (Grade 1.1 to 1.6)	25	18.5	6.5	2.28
Below $\bar{X}$ - .675 s. d. (Grade 1.0 and below)	13	18.5	5.5	1.63
		Chi-square = 6.63*		

*p lies between .05 and .02; d. f. = 3.

TABLE 7

DISTRIBUTION OF SCORES ON TEST FOR VISUAL-MOTOR INTEGRATION

	Observed	Expected	O-E	$(O-E)^2/E$
Above $\bar{X}$ + .675 s. d. (Age 7-0 and over)	19	18.5	.5	.25
$\bar{X}$ to ($\bar{X}$ + .675 s. d.) (6-2 to 6-9)	9	18.5	9.5	4.88
$\bar{X}$ to ($\bar{X}$ - .675 s. d.) (5-5 to 6-1)	19	18.5	.5	.01
Below $\bar{X}$ - .675 s. d. (Age 5-4 and below)	27	18.5	8.5	3.91
		Chi-square = 8.81*		

*$p < .02$, d. f. = 3.

VISUAL-MOTOR INTEGRATION

Although these data were lost so far as the possibility of incorporating them in the factorial analysis of variance designs, the importance attached to impairment on this dimension as having diagnostic implications for the etiology or mental retardation demanded some attention to the material.

In order to evaluate the charge that children of ethnic minority groups are 'different' and are placed in these programs in disproportionate number, a fourfold table tallying frequencies of whites and ethnic minorities who scored high and low on copying the designs was constructed. These data are presented in Table 8. Chi-square was computed for these data, and the statistical test of the null hypothesis for this distribution (i. e., there are no actual differences between the observed and the expected frequencies) indicated that it might safely be rejected.

TABLE 8

CHI-SQUARE COMPARISON OF WHITE AND ETHNIC MINORITIES ON VISUAL-MOTOR INTEGRATION TEST

	Whites	Minorities	
VMI High	8	21	
VMI Low	26	19	Chi-square = 6.473 $p < .01$, d. f. = 1 (One-tailed test) N = 74

A similar table was set up to compare distribution by class. These data are presented in Table 9. In this case, the null hypothesis was accepted; there were no actual differences between obtained and expected frequencies.

TABLE 9

CHI-SQUARE COMPARISON OF LOWER AND MIDDLE CLASS ON VISUAL-MOTOR INTEGRATION TEST

	Lower	Middle	
VMI High	5	3	
VMI Low	9	17	Chi-square = .970 Not significant (Yates correction for continuity applied) N = 34

A 3 X 3 table was constructed to tally scores on the Copying Design Test in relation to Piaget's stages. These data are presented in Table 10. The cell frequencies by observation indicated the relatedness of these classifications. The null hypothesis, tested by computing Chi-square, was rejected. That is, there were differences between observed and expected frequencies. Chi-square of this magnitude is evidence for correlation or association between these categories.

TABLE 10

CHI-SQUARE COMPARISON OF RATINGS
ON CONCEPTION OF SPACE AND
VISUAL-MOTOR INTEGRATION

	Piaget's Stages			
VMI Age	IIA	IIB	III	
Below 5-3	18	10	0	Chi-square = 55.85
5-4 to 6-10	2	14	3	d.f. = 4, $p < .001$
6-11 and over	0	7	20	N = 74

CONCEPTION OF SPACE

Further comparisons of the Piagetian ratings on conception of space as it was related to the measure of perceptual ability were completed. Chi-square was computed on the 3 X 2 table in which ratings on space conception were paired with performance on the Hidden Figures. These data are presented in Table 11. Again, there appeared to be a significant relationship between these measures, although not to the degree indicated between the Visual-Motor Integration Test and ratings on Conception of Space. Since all three of these are measures of perception, their apparent lack of independence might have been expected. The problem lies in the direction of the four Stage III pupils who scored in the bottom half on finding the figures and in the three primitive perceivers of space, as indicated by the IIA ratings, who did so well. This issue is discussed further in Chapter V.

TABLE 11

CHI-SQUARE COMPARISON OF RATINGS
ON CONCEPTION OF SPACE AND
HIDDEN FIGURES SCORES

	Piaget Stages			
Scores	IIA	IIB	III	
8 and below	17	14	4	Chi-square = 18.20
9 and above	3	17	19	$p < .001$, d.f. = 2 N = 74

The questions which have been raised about Piaget's "ages and stages" as they relate to intelligence as measured by tests and the maturational hypothesis were approached through the Chi-square method also. The 3 X 3 contingency tables relating stages in conception of space with age and with IQ are presented in Tables 12 and 13 respectively.

TABLE 12

CHI-SQUARE COMPARISON OF RATINGS ON
CONCEPTION OF SPACE WITH
CHRONOLOGICAL AGE

	Piaget Stages			
Age	IIA	IIB	III	
10 and below	9	7	5	
10-1 to 11-6	6	8	11	Chi-square = 7.243
11-7 and over	5	16	7	Not significant, d.f. = 4 N = 74

TABLE 13

CHI-SQUARE COMPARISON OF RATINGS ON CONCEPTION OF SPACE WITH IQ

IQ	IIA	IIB	III	
64 and below	8	6	0	
65-74	9	14	9	Chi-square = 14.878 $p < .01$, d.f. = 4 N = 74
75 and above	3	11	14	

It may be observed that while there was a clear association between intelligence test scores and stage of development in the Conception of Space, there was no apparent relationship with chronological age for this sample.

Further investigation of the significance of perceptual handicap in association with mental retardation was available by application of the Piaget ratings and Hidden Figure scores to see whether these categorizations differentiated the white and the ethnic minority groups. This constituted a check on whether overlapping function was measured by these different methods and also verified the two populations suggested by the Visual Motor Integration Test (Table 8). The frequencies of the Piaget ratings for white and ethnic minority students are presented in Table 14.

The relationship of scores on the Hidden Figures Test to a similar breakdown of population is presented in Table 15.

TABLE 14

CHI-SQUARE COMPARISON OF WHITE AND ETHNIC MINORITIES ON CONCEPTION OF SPACE

	Piaget Stages			
	IIA	IIB	III	
Whites	15	13	6	Chi-square = 9.125 $p < .01$, d.f. = 2
Ethnic Minorities	5	18	17	(one tailed test) N = 74

TABLE 15

CHI-SQUARE COMPARISON OF WHITE AND ETHNIC MINORITIES ON HIDDEN FIGURES TEST

	Scores		
	8 and under	9 and over	
Whites	18	16	Chi-square = .125 Not significant, d.f. = 1
Ethnic Minorities	16	24	N = 74

The Piaget ratings and Visual-Motor Integration Test age scores were derived from use of the same materials by the students. These "tests" were constituted by scoring considerations: in the case of the Visual Motor Integration Test, accuracy of representation was the sole criterion; for the Piaget ratings, attention was given to process aspects of the student's drawings in terms of how the figures were related. In both of these tests, however, scoring depended on motoric response to visually presented stimuli. In the indication of the Hidden Figures, motoric response was minimized. The significance of these results is discussed further in Chapter V.

SERIATION: RELATED TO VISUAL-MOTOR INTEGRATION AND SPACE CONCEPTION

Since the data on the Visual Motor Integration Test age scores and the ratings on Conception of Space were not amenable for use in the major analysis presented below, contingency tables relating these dimensions to performance on the Seriation Test were constructed and cell frequencies tabulated so that probability estimates could be calculated regarding the nature of the distribution by Chi-square. Table 16 presents the information on Seriation Test and Visual Motor Integration Test age scores.

TABLE 16

CHI-SQUARE COMPARISON OF SERIATION TEST AND VISUAL MOTOR INTEGRATION TEST AGE SCORES

	Seriation Low	Seriation High	
VMI Low	29	16	Chi-square = 15.821 $p < .001$, d.f. = 1
VMI High	5	24	N = 74

In spite of significant association between Visual Motor Integration Test score, observation of the cell frequencies in Table 16 suggested that it was more likely for pupils who function relatively well on the Seriation Test to have visual-motor impairment than those high on visual-motor to show severe disability in the ordering operations on the Seriation Test. Nevertheless, the highly significant relationship between these factors was substantiated by Chi-square. From this, it was possible to estimate tetrachoric r, an expression of relationship comparable with the Pearson product moment correlation.[230] For the data

[230] H. E. Garrett, Statistics in Psychology and Education, 5th ed. (David McKay Co., Inc., New York) pp. 386-388 and 460.

in Table 16, r_t = .70. This estimate was remarkably close to the correlation of .65 between Seriation Test and perceptual ability, as indicated by the Hidden Figures method (reported in the following section).

A similarly significant association was determined for the ratings on conception of space and Seriation Test scores, as indicated in Table 17.

TABLE 17

CHI-SQUARE COMPARISON OF SERIATION TEST AND CONCEPTION OF SPACE RATINGS

	Piaget Stages			
	IIA	IIB	III	
ST Low	15	15	14	Chi-square = 15.034
ST High	5	16	19	$p < .001$, d.f. = 2
				N = 74

CORRELATIONAL ANALYSIS

Pearson product moment correlation coefficients were computed for each pair of test scores to provide a direct expression of the degree of relationship. The maturational hypothesis suggested the need for using age as a factor in the correlational matrix presented in Table 16. These data indicated particularly high correlations between seriation and perception (as measured by the Hidden Figures), seriation and arithmetic, and perception and arithmetic. Piagetian theory on the development of number rests on the assumption that the child's internalization of grouping, ordering, and counting actions give rise to

arithmetic operations.[231] The pattern which emerged in this correlational analysis confirmed the pre-eminence of this kind of inter-relatedness underlying the development of abstract number conception.

TABLE 18

MATRIX OF PEARSON PRODUCT MOMENT CORRELATIONS

	IQ	Seriation	Perception	Reading	Arithmetic
Seriation	.398	--	--	--	--
Perception	.433	.654	--	--	--
Reading	.008*	.453	.426	--	--
Arithmetic	.462	.716	.632	.034*	--
Age	-.089*	.483	.330	.521	.558

*Not significant; all other correlations are highly significant, $p < .005$, d.f. = 73.

Since the IQ score is itself an index of relationship which takes age into account, lack of correlation between age and intelligence ($r = -.089$) was fully in accord with expectation. There was less clarity on the negligible relationship between reading and intelligence ($r = .008$). The restricted range on the measure of intelligence yielded a relatively homogeneous population in this regard thereby tending to reduce the strength of relationship with academic achievement. There was, however, a substantial correlation between intelligence and arithmetic achievement ($r = .462$).

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231 J. Piaget, The Child's Conception of Number, (Humanities, New York, 1952).

Partial Correlations

Since seriation and perception were both correlated with intelligence, intelligence was statistically eliminated by the computation of the partial correlation coefficient. Further, the relationship of seriation and perception with reading and arithmetic was computed by this method. Both seriation and perception remained as highly significant variables. These data are presented in Table 19. A t-test was used to determine whether these relationships differed significantly from zero.[232]

TABLE 19

PARTIAL CORRELATIONS: SERIATION AND PERCEPTION WITH ACHIEVEMENT (INTELLIGENCE ELIMINATED)

	Perception	Arithmetic	Reading
Seriation	.512*	.654*	.485*
Perception	--	.676*	.521*

*$p < .0005$ for all of these relationships.

Similarly, since both seriating and perceptual ability increase with age and were shown to be significantly correlated with age in this population, partial correlations were computed for this factor. These data are presented in Table 20.

Using a variance interpretation of these partial correlations, as suggested by Ferguson,[233] it is appropriate to state that of the

[232] Ferguson, op. cit., p. 291.

[233] Ibid., p. 291.

TABLE 20

PARTIAL CORRELATIONS: SERIATION AND PERCEPTION WITH ACHIEVEMENT (AGE ELIMINATED)

	Perception	Arithmetic	Reading
Seriation	.597*	.614*	.315**
Perception	---	.572*	.446*

*$p < .0005$; **$p < .005$.

total association between seriation and perception, twenty-five per cent resulted from the effects of intelligence; the remaining seventy-five per cent of the association resulted from other factors. By the same process, it may be inferred that for this group, only ten per cent of the total association between seriation and perception resulted from the effects of age; the remaining ninety per cent of the association resulted from other factors.

The partial correlation coefficient for seriation and IQ, with perception eliminated was at .169, a negligible relationship. The variance interpretation of this suggests that of the total association between seriation and IQ, eighty-two per cent resulted from the effects of perceptual ability, as measured by the Hidden Figures method.

The partial correlation for perception and IQ, with seriation eliminated was .249, a slight, but significant relationship. Applying the variance interpretation to this, it appears that of the total association between perception and IQ, sixty-seven per cent resulted from the effects of seriation.

ANALYSIS OF RESULTS

Each of the ten analysis of variance studies is presented, seriatim. The data for each study is presented in tabular form: Part A shows the mean Seriation Test Score and frequency in each cell; Part B presents the analysis of variance. The discussion in this section is organized with reference to the data in each of the tables.

The material on the Seriation Test scores as the dependent variable in a factorial analysis of variance design in which the independent dimensions were perception and IQ is presented in Table 21. Three hypotheses were tested simultaneously in this design: the effects of perception, the effects of IQ, and the significance of the interaction between these two variables. The statistical propositions, stated as null hypotheses, were: (1) there are no significant differences in Seriation Test scores between children of high or low perceptual ability; (2) there are no significant differences in Seriation Test scores between children of higher or lower IQ; (3) there is no significant effect on Seriation Test scores associated with the interaction of perception and intelligence.

Unfortunately, some of the original data was lost as a result of the need to reduce the imbalance in the obtained distribution. The original cell frequencies were: low perception, low IQ = 28; high perception, low IQ = 12, high IQ, low perception = 12; and high IQ, high perception = 22. (Chi-square for this distribution = 10.43, with p lying between .02 and .01, which is, in itself, a statement of the significance of the relationship of the dimensions on which these

TABLE 21
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED
BY PERCEPTION AND IQ

		Perception	
		Low	High
IQ	Low	$\bar{X}$ = 47.70 N = 16	$\bar{X}$ = 90.66 N = 12
	High	$\bar{X}$ = 80.83 N = 12	$\bar{X}$ = 90.35 N = 16

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
Perception	1	684.54	25.49*
IQ	1	263.46	9.05**
Perception X IQ	1	285.38	10.19**
Error	52	20.03	

*$p < .001$
**$p < .01$

categories were based). The study, as presented, was based on 56 subjects, selected from the total sample by use of a table of random numbers to strike out the required number of cases in the low IQ, low perception and high IQ, high perception cells.

From the analysis of this data, it was concluded that all three of the null hypotheses could be rejected with a high level of confidence. These results appeared to confirm Piaget's interpretation of seriation as being largely a perceptual function.[234] Nonetheless, the complexity of development seemed to be based on the inter-relatedness of function in which multiple strands were finely woven together.

The data on the Seriation Test scores as the dependent variable on the independent variables of sex and IQ is presented in Table 22. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores between boys and girls; (2) there are no significant differences in Seriation Test scores between those of high and low IQ; and (3) there is no significant effect on Seriation Test scores associated with the interaction of sex and IQ. This study is based on the full sample of 74 students.

From the analysis, it was concluded that only the effects of IQ produced differences which substantiated the rejection of the null hypothesis. Although the group mean scores for girls were higher than that for the boys, the effects were not statistically significant and the null hypothesis was accepted. The interaction for sex X IQ appeared to be so slight as to be well within the probability of chance

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[234] cf supra, p. 11 and 46.

TABLE 22
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED
BY SEX AND IQ

		Boys	Girls
IQ	Low	$\bar{X}$ = 61.45 N = 20	$\bar{X}$ = 66.26 N = 23
	High	$\bar{X}$ = 84.11 N = 17	$\bar{X}$ = 92.36 N = 14

PART B
ANALYSIS OF VARIANCE

Source	df	ms	F
IQ	1	594.34	14.37*
Sex	1	42.64	1.03**
IQ X Sex	1	2.96	.07**
Error	70	41.34	

* $p < .001$

** Not significant

fluctuations. Therefore, the null hypothesis for this factor was accepted.

Table 23 presents the data on Seriation Test scores as the dependent variable, on the independent dimensions of sex and perception. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores between boys and girls; (2) there are no significant differences in Seriation Test scores between those of higher and lower perceptual ability; and (3) there is no significant effect on Seriation Test scores associated with the interaction of sex and perception. This study is based on the total sample of 74 students.

From the analysis, it was concluded that only the second of the null hypotheses might be rejected with confidence. The effects of perception on seriation might have been expected to occur less than one time in a thousand by chance. However, in both of the other tests, relative to the effects of sex and sex X perception, there were no significant differences and, therefore, the null hypotheses were accepted. Again, the mean scores for the girls were higher than those for the boys, but not of the magnitude to yield statistical significance.

Table 24 presents the data on Seriation Test scores as the dependent variable on the independent variables of socio-economic class and arithmetic achievement test scores. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores between children from lower class or middle class homes; (2) there are no significant differences in Seriation Test scores between those who score high and low on the arithmetic achievement test; and

TABLE 23
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED
BY SEX AND PERCEPTION

		Boys	Girls
Perception	Low	$\bar{X} = 54.88$ $N = 17$	$\bar{X} = 61.52$ $N = 21$
	High	$\bar{X} = 86.30$ $N = 20$	$\bar{X} = 95.31$ $N = 16$

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
Perception	1	1064.57	31.12*
Sex	1	62.72	1.83**
Perception X Sex	1	--	--**
Error	70	34.21	

*$p < .001$
**Not significant

TABLE 24
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED BY CLASS AND ARITHMETIC ACHIEVEMENT

		Lower Class	Middle Class
Arithmetic Achievement	Low	$\bar{X} = 55.0$ $N = 7$	$\bar{X} = 39.1$ $N = 11$
	High	$\bar{X} = 90.86$ $N = 7$	$\bar{X} = 83.56$ $N = 9$

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
Arithmetic	1	1613.23	35.96*
Class	1	134.68	3.02**
Class X Achievement	1	17.69	.39**
Error	30	44.86	

*$p < .001$

**Not significant

(3) there is no significant effect on Seriation Test scores associated with the interaction of social class membership and school achievement as indicated by this arithmetic test. This study was limited of necessity to 34 students: the 20 middle class and 14 lower class samples.

From the analysis, it was concluded that only the effects associated with arithmetic achievement were such that the null hypothesis could be rejected with confidence. The effects of social class and those of class X arithmetic did not reach the level at which the null might be rejected; however, the differences in group mean scores favoring the lower class groups approached significance. (The t-test for difference between the means yielded p between .05 and .01.) The implications of these differences are discussed in Chapter V.

Table 25 presents the data on Seriation Test scores distributed by socio-economic class and IQ. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores between children from lower class and middle class homes; (2) there are no significant differences in Seriation Test scores between children who have lower or higher IQ's; (3) there is no significant effect on Seriation Test scores associated with the interaction of social class membership and IQ. This study was based on 34 white students; the 20 middle class and 14 lower class pupils.

From the analysis, it was concluded that only the effects associated with IQ produced statistically significant results, warranting rejection of the null hypothesis. As regards the effects of social class or the effects of the interaction between class and IQ, the null

TABLE 25
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED
BY CLASS AND IQ

		Lower Class	Middle Class
IQ	Low	$\bar{X} = 56.57$ $N = 7$	$\bar{X} = 48.38$ $N = 13$
	High	$\bar{X} = 89.28$ $N = 7$	$\bar{X} = 79.0$ $N = 7$

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
IQ	1	1002.68	16.49*
Class	1	85.29	1.40**
IQ X Class	1	1.07	.00**
Error	30	60.79	

*$p < .001$

**Not significant

hypotheses were accepted. Again, however, it was noted that the differences in group mean scores favored the lower class groups. The apparent consistency of small, albeit not statistically significant, differences is discussed in Chapter V.

Table 26 presents the data on Seriation Test scores distributed as a function of ethnic group and IQ. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores among children from the three ethnic groups represented; (2) there are no significant differences in Seriation Test scores between children of higher and lower IQ; (3) there is no significant effect on Seriation Test scores associated with the interaction of ethnic group membership and IQ. This study was based on a total of 54 students (20 Negro, 20 Mexican and 14 whites) all from lower class homes, to avoid any possible contamination of effects of social class.

From the analysis, it was concluded that, again, only the effects associated with IQ produced statistically significant results which warranted rejection of the null hypothesis. In the case of the effects of ethnic group membership and the interaction between ethnic group and IQ, the null hypotheses were accepted.

Table 27 presents the data on Seriation Test scores distributed by ethnic group and perceptual ability as assessed by the Hidden Figures Test. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores among children from the three ethnic groups represented; (2) there are no significant differences in Seriation Test scores between children of higher and lower

TABLE 26
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED BY ETHNIC GROUP AND IQ

		Negro	White	Mexican
IQ	Low	$\bar{X} = 78.20$ $N = 9$	$\bar{X} = 56.57$ $N = 7$	$\bar{X} = 76.58$ $N = 12$
	High	$\bar{X} = 82.90$ $N = 11$	$\bar{X} = 89.29$ $N = 7$	$\bar{X} = 92.25$ $N = 8$

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
IQ	1	476.10	7.29*
Ethnic	2	71.48	1.09**
IQ X Ethnic	2	92.94	1.42**
Error	48	65.30	

*$p < .01$
**Not significant

TABLE 27
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED BY
ETHNIC GROUP AND PERCEPTUAL ABILITY

		Negro	White	Mexican
Perception	Low	$\bar{X} = 72.70$ $N = 10$	$\bar{X} = 61.0$ $N = 10$	$\bar{X} = 70.25$ $N = 8$
	High	$\bar{X} = 88.90$ $N = 10$	$\bar{X} = 89.40$ $N = 10$	$\bar{X} = 91.25$ $N = 12$

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
Perception	1	717.23	24.25*
Ethnic Group	2	20.73	.70**
Perception X Ethnic	2	18.84	.64**
Error	54	29.58	

*$p < .001$
** Not significant

perceptual ability; (3) there is no significant effect on Seriation Test scores associated with the interaction of ethnic group membership and perceptual ability. This study was based on a total of 60 students. The 20 white subjects were selected from the lower and middle class groups by using a table of random numbers in order to equalize the size of the three ethnic troups.

From the analysis, it was concluded that only the factor of perceptual ability contributed to the extent that warranted rejection of the null. The null hypotheses were accepted in regard to the influence of ethnic group membership and the interaction between ethnic group and perceptual ability.

Table 28 presents the data on the distribution of Seriation Test scores as a function of ethnic group membership and arithmetic achievement test score. The null hypothese tested in study were: (1) there are no significant differences in Seriation Test scores among children from the three ethnic groups represented; (2) there are no significant differences in Seriation Test scores between children who score higher and those who are lower on the arithmetic achievement test; (3) there is no significant effect on Seriation Test scores associated with the interaction between ethnic group membership and arithmetic achievement.

From the analysis, it was concluded that only the effects associated with school achievement as indicated by the arithmetic test produced statistically significant results which justified rejection of the null hypothesis. The effects of both ethnic group membership and the interaction between ethnic group and arithmetic achievement were negligible; the null hypotheses were accepted.

TABLE 28
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED BY ETHNIC GROUP AND ARITHMETIC ACHIEVEMENT

	Negro	White	Mexican
Arithmetic Low	$\bar{X}$ = 71.18 N = 11	$\bar{X}$ = 59.55 N = 11	$\bar{X}$ = 72.0 N = 10
Arithmetic High	$\bar{X}$ = 92.55 N = 9	$\bar{X}$ = 91.44 N = 9	$\bar{X}$ = 93.70 N = 10

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
Arithmetic	1	936.62	17.39*
Ethnic Group	2	31.90	.59**
Arithmetic X Ethnic	2	17.90	.33**
Error	54	53.85	

*$p \leq .001$
**Not significant

Table 29 presents the Seriation Test scores distributed by age and ethnic group. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores among children from the three ethnic groups represented; (2) there are no significant differences in Seriation Test scores between younger and older children; and (3) there is no significant effect on Seriation Test scores associated with the interaction of ethnic group and age. This analysis was computed on the basis of data on 70 students; it was necessary to reduce the white sample by using a table of random numbers to strike out four subjects because of the imbalanced distribution which otherwise resulted.

From the analysis, it was concluded that only the effects associated with age produced differences to the degree that they were statistically significant and indicated rejection of the null hypothesis. For the effects of both ethnic group and the interaction of age and ethnic group, the differences observed were within the probability of chance fluctuations; the null hypotheses were accepted.

Table 30 presents the data on the distribution of Seriation Test scores as a function of age and IQ. The null hypotheses for this study were: (1) there are no significant differences in Seriation Test scores between older and younger children; (2) there are no significant differences in Seriation Test scores between children who have higher and lower IQ's; and (3) there are no significant effects on Seriation Test scores associated with the interaction between age and IQ. The cell frequencies in this distribution were sufficiently balanced that it was possible to utilize the total sample of 74 subjects for this

TABLE 29
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED
BY ETHNIC GROUP AND AGE

		Negro	White	Mexican
Age	Under 11	$\bar{X}$ = 71.90 N = 10	$\bar{X}$ = 44.60 N = 15	$\bar{X}$ = 80.5 N = 12
	Over 11	$\bar{X}$ = 89.70 N = 10	$\bar{X}$ = 84.73 N = 15	$\bar{X}$ = 86.38 N = 8

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
Age	1	678.16	11.98*
Ethnic Group	2	106.57	1.88**
Age X Ethnic Group	2	151.37	2.68**
Error	64	56.58	

*$p < .001$

**Not significant

TABLE 30
PART A

MEAN SERIATION TEST SCORES DISTRIBUTED
BY AGE AND IQ

		Age	
		Under 11	Over 11
IQ	Low	$\bar{X}$ = 46.0 N = 20	$\bar{X}$ = 77.63 N = 20
	High	$\bar{X}$ = 86.77 N = 18	$\bar{X}$ = 90.5 N = 16

PART B

ANALYSIS OF VARIANCE

Source	df	ms	F
IQ	1	719.54	25.41*
Age	1	312.59	11.03**
IQ X Age	1	194.40	6.85***
Error	70	28.31	

*$p < .001$
**$p < .01$
***$p < .05$

analysis.

From the analysis, it was concluded that the first two of the null hypotheses could be rejected with confidence. The effects of IQ were most pronounced; the F-test indicated that such differences occur less than one time in a thousand by chance. The effects of age were somewhat less powerful in this study, being of the magnitude that might have occurred less than one time in a hundred by chance. The effects of the interaction between age and IQ were further reduced, although still significant, with the probability of chance occurrence less than five times out of a hundred.

SUMMARY

The results and statistical analyses of this investigation of seriation and perception in the functioning of a group of 74 EMR elementary level pupils have been presented in this Chapter. It was demonstrated that scores on four of the measures employed provided non-parametric confirmation of the distribution assumption underlying the analysis of variance method.

The matrix of Pearson product moment correlation coefficients computed on the data described highly significant inter-relationships among the factors under consideration. Particularly, there were substantial relationships between seriation and perception, seriation and arithmetic, and perception and arithmetic. The partial correlation procedure was used to provide for the statistical elimination of age and IQ in determining the relationship between seriation and perception. Partial correlations were also computed for seriation and IQ,

eliminating perception, and for perception and IQ, eliminating seriation. These substantiated considerable overlap between seriation and perception.

The data available from copying designs, scored by age norms for visual-motor integration and also rated according to Piaget's stages in the development of conception of space, were tallied and Chi-square comparisons were computed on a variety of dimensions. The distribution of scores on both visual-motor integration and conception of space differentiated between the whites and those from ethnic minorities. The Seriation Test scores were related to these aspects of perceptual function by Chi-square.

Ten factorial analysis of variance studies were reported in which seriation, as the dependent variable, was analyzed in terms of the effects of IQ, perception, sex, social class, ethnic group, arithmetic achievement, and age, as the independent variables. The most significant effect were demonstrated to be associated with perception and arithmetic achievement. IQ and age were also highly significant factors, although to a lesser extent.

The F-test failed to support any statistical significance for the effects of ethnic group, social class, or sex on seriating ability. However, there were consistent indications of differences in group mean scores: girls performed somewhat better than boys on the Seriation Test; the lower class group did better than the middle class; and, in the analysis of ethnic groups, the white groups had mean scores below those of the ethnic minority groups.

CHAPTER V

DISCUSSION OF RESULTS

The purpose of the study was to investigate the relationship of seriation and perception and intelligence, to determine the relationship of these dimensions to actual academic achievement, and to analyze the socio-cultural and ethnic factors in their effects on the variety of measures under consideration in a sample of the population identified as 'educable mentally retarded'. The problems involved in defining this dubious entity, the questions concerning the nature and assessment of intelligence, and developmental constructs relating perception and seriation to these issues were discussed in the initial chapters of this report. The design of the study was outlined in Chapter III and the findings and statistical analysis of the data were presented in Chapter IV. This Chapter consists of discussion of the investigation in terms of the meaning and significance of the results. The methods of statistical analysis yield atomistic answers to macroscopic questions. In order to render these results more relevant and coherent, the following discussion is organized with reference to the questions about the relationships among the variables studied, as specified in Chapter I.[235] The implications of the findings reported are summarized in Chapter VI of this report.

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235 Cf. supra., p. 15

SERIATION AND PERCEPTION

As previously noted and discussed, in the Piagetian formulation, seriation is related to perception and develops from the 'perceptual configuration' as compared with classification, which is directly associated with language development. The results obtained in this study clearly substantiated a close relationship, statistically highly significant, between seriation and perception. (See Tables 16, 17, 21, et. seqq.)

In the Chi-square comparison of seriation and visual-motor age scores, the significance of the association was such that it might be expected to occur less than one time in a thousand by chance. Tetrachoric correlation of .70 was reported for this data, which was closely comparable for the relationship between seriation and another measure of perceptual ability, the Hidden Figures, for which r = .654. Similarly, the Chi-square comparison of Piaget's ratings on the child's development of conception of space and Seriation Test scores yielded a highly significant relationship. The relative stability of such a relationship, as indicated by three varying measures, was initially impressive.

However, it must be pointed out that, in an analogue to the problems which beset learning theorists, there is no measurement possible without some performance on the part of the subject. The dilemma as to how much of what function is actually being measured remains unresolved.

It may be more justifiable to argue that the 'real' functions

measured by all of these instruments overlap to the extent that these cannot be considered as independent tests. In the Seriation Test, the tasks consist of matching figures, sequencing by size, etc. Perceptual activity is clearly an essential component of performance on the seriation problems. This is equally true in the case of the original studies reported by Inhelder and Piaget.[236] Subjects arranged a series of sticks, graduated in size, inserted objects of varying size in a prearranged series, and assessment of multidimensional seriation was based on a problem requiring arrangement of forty-nine leaves presented in seven sizes and seven shades of green.[237] These are tasks requiring 'perceptual activity'; their solution depends on the discriminability of differences among the stimuli presented, as well as the determination of the relationships among them. Moreover, at the same time, a relational language (more, less, large, small, same, different, etc., in comparative and superlative terms) is a basic component in such problem solving. While the words, as such, may not be required, some system of codification for the material is essential for accurate completion of the seriation tasks. It appears that there is little ground on which to allege an arbitrary categorization of the underlying ability.

The nature of the relationship between seriation and perception was examined by the variance interpretation of the partial correlation coefficients (Tables 19 and 20). This suggested that of the total association between seriation and percepton, twenty-five per cent resulted

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[236] Cf. supra., pp. 45-50.

[237] Ibid.

from the effects of intelligence, and only ten per cent resulted from the effects of age. That is, in this population, with a restricted range of intelligence, as estimated by IQ tests, there was, nonetheless, evidence of a highly significant contribution of the effects of intelligence on the scores of tests assessing both perceptual competency and seriating ability. The effects of age remained relevant for this population, contributing ten per cent of the variance in measures of perception and seriation, but intelligence obviously constituted a far more significant source of the total variance.

Piaget suggests, in discussing the developmental stages in seriating ability, that the perceptibility of size differences influences the age at which the stage may appear, but not the order of appearance. The hypothesis that perceptual development is a necessary, but not sufficient, cause for the development of seriation seems to have rational appeal. This is challenged, however, by observation of the cell frequencies in the Chi-square comparison of Seriation Test and Visual Motor Integration Test age scores (Table 16) and in the Chi-square comparison of Seriation Test and Conception of Space ratings (Table 17). In spite of the statistically significant association indicated, inconsistencies were pointed out by the cell frequencies for poor perceptual development-high seriation or the converse: high perceptual development-low seriation. It appeared far more likely for pupils who did relatively well on the Seriation Test to have a serious degree of visual-motor impairment, than it was for those who did well on the Visual Motor Integration Test to show marked disability on the Seriation Test.

If, as is claimed, seriation is indeed a dependent variable on

perception, a variance interpretation of the correlation coefficient between them is in order. Based on this data, there appeared to be only a limited confirmation of Piaget's hypothesis, and that requires further qualification. The interpretation of the square of the correlation as the percentage of variance in seriation which was predictable by, or attributable to, variance in perception indicated that about forty-three per cent of the variance in seriation was accounted for on this basis; but fifty-seven per cent of the variance in seriation then remained unexplained, and was related to other factors or variables.

PERCEPTION AND INTELLIGENCE

The measures of perceptual development reported in this study encompassed (1) the accuracy with which designs of increasing complexity were reporduced; (2) ratings based on Piaget's theory of the child's development of conception of space; and, (3) Hidden Figures, in which a model constituted part of a more intricate figure. The Chi-square analyses of the association among these three measures were all statistically significant ($p < .001$) and justified the interpretation of the data in terms of a common factor of perceptual adequacy underlying performance.

However, again the question of the 'purity' of these measures is relevant. Conception of space is not purely perceptual activity, independent of the development of intelligence. The data substantiating this, contrary to Piaget's theory, was apparent in these studies. (See Tables 12 and 13.) The Chi-square comparison of ratings of the Conception of Space with chronological age did not reach the level of

statistical significance for this population. On the other hand, the Chi-square comparison of conception of space with IQ was statistically significant ($p < .01$). This is even more impressive when the fact is taken into consideration that the restricted range in the measure of intelligence tends to limit expression of relationship, while the age range (8-6 to 13-3) in this sample does permit sufficient heterogeneity to be sensitive to statistical expressions of association.

The relationship between scores on the Hidden Figures and IQ was expressed in the Pearson product moment correlation coefficient .433. This may be compared with the other correlations for this measure of perception: with seriation, $r = .654$; with reading, $r = .426$; with arithmetic, $r = .632$; and with age, $r = .330$. All of these relationships were statistically significant ($p < .005$). However, to appreciate the full import of the differences among these correlation coefficients, the variance interpretation is useful in demonstrating that intelligence accounted for almost twice as much of the total variance (nineteen per cent) in perception as does age (eleven per cent), for example. This data appears to revive and validate the outmoded mental age concept to some extent!

By the use of levels of perceptual ability and IQ as the control or independent variables, in the analysis of variance studies, it was possible to get a closer estimate of the true error variance on seriation, as the dependent, or criterion variable (Table 21). Both perception and IQ appeared to contribute significantly in their effects on seriation. But perception produced a much larger F term and the interaction term for perception X IQ was greater than the term for IQ alone.

The inter-relationships were actually such that Piaget's rigorous differentiation between perception and intelligence as structurally independent modes of adaptation seems to be concerned with phenomena which are more apparent than real; the value of such a conceptual distinction seems doubtful. The data obtained in this study would add to Flavell's defense for the inclusion of Piaget's theory and experimentation on perceptual problems as "idiosyncracies of the system".[238]

SERIATION AND INTELLIGENCE

In the preceding sections, seriation has been shown to be significantly related to perception; the relationship to intelligence is also demonstrated in these data, albeit to a lesser degree. The relationship between scores on the Seriation Test and IQ was expressed in the Pearson product moment correlation coefficient .398. This may be compared with the other measures associated with seriation: with perception, $r = .654$; with reading, $r = .453$; with arithmetic, $r = .716$; and with age, $r = .483$. In spite of the fact that all of these relationships were statistically significant ($p < .005$), it may be noted by reference to the variance interpretation of these correlations that IQ contributed only sixteen per cent of the total variance in seriation, as compared with perception, which accounted for about forty-three per cent of the variance. The fact that age was more a factor in its relationship with seriation ($r = .483$) than it was with perception ($r = .330$), is of the greatest interest in this data.

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[238] Flavell, op. cit., p. 231.

There remained only a negligible relationship between seriation and IQ (at .169) when the effects of perception were eliminated in the partial correlation. The variance interpretation of this partial correlation suggested that of the total association between seriation and IQ, eighty-two per cent resulted from the effects of perceptual ability, as measured in this study by the Hidden Figures. This is quite consistent with Nelson's conclusion that "the relationship between seriation and verbal abilities seemed lower than the correlation between seriation and perceptual tasks".[239] It must be remembered, however, that in eliminating the effects of perception (as assessed in this study), it was possible that a particular factor, or kind of intelligence was removed.

The effects of age and IQ were both significant in contributing to variance in seriation (Table 30). IQ was highly significant ($p < .001$); age contributed to a lesser degree ($p < .01$); and the interaction term for IQ X age was reduced to the level where it merely approached significance ($p < .05$).

Piaget, on the other hand, describes marked differences in the ability to discriminate and seriate in children grouped by age, from four to seven.[240] He contends that the stages observed are for the most part attributable to maturation and that differences in IQ and environmental stimulation do not obliterate differences which are solely a function of growth. Elkind claimed verification for this maturational

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[239] Nelson, op. cit., p. 76.

[240] Cf. supra., pp. 45-50

hypothesis in an experiment in which he compared four and five year olds from homes of professionals and upper middle class with six year olds from a lower socio-economic group.[241] Despite the absence of measurement, he assumed a higher level of intelligence for those from the socially advantaged homes. The most tenable statistical hypothesis, on the contrary, would be that the children in both of his groups were preponderantly of average intelligence. Experimentation with children whose functioning is within the broad range of 'normal' would tend to obliterate the highly significant effects of intelligence, as seen in the population under consideration in this study, in favor of the developmental changes occurring with age. The importance of maturation alone was impugned by the results which were so dramatic on this deviant group.

The consistency with which IQ emerged as a highly significant factor (Tables 21, 22, 25, and 26) was overwhelming evidence of the prepotency of this dimension. The fact that IQ contributed in large measure to the effects on perceptual and seriating ability and appeared to have predictive value for estimates of performance on both the tests of perception and seriation provided added confirmation of the utility of the IQ and justified the continued use of these empirically developed, global assessments of inadequately defined ability or abilities. There was in this data, notwithstanding the intellectually limited population, positive correlation among the measures of performance in seriation, perceptual ability and intelligence which recall and confirm theories

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[241] D. Elkind, "Discrimination, Seriation, and Numeration of Size and Dimensional Differences in Young Children", Journal of Genetic Psychology, 1964: 104, 275-296.

of an underlying unitary faculty or group factor - reminiscent of Spearman's g or capable of interpretation in one of the more current theories of hierarchical intellectual structure.

However, the added dimension which the study of seriation as a specific or component ability brings to educational practice is most clearly apparent in relation to the data gathered by measures of academic achievement.

ACADEMIC ACHIEVEMENT

The ability of the Seriation Test to predict academic achievement appeared to be even stronger than that of the powerful and ubiquitous IQ. Table 31 recapitulates the Pearson product moment correlations for seriation and IQ with scores on reading and arithmetic.

TABLE 31

PEARSON PRODUCT MOMENT CORRELATIONS OF SERIATION AND IQ WITH ACADEMIC ACHIEVEMENT

	IQ	Perception	Reading	Arithmetic
Seriation	.398	.654	.453	.716
IQ	---	.433	.008*	.462

*Not significant, all others at $p < .005$

Moreover, in the partial correlation of seriation and arithmetic and seriation and reading, with the effects of IQ statistically eliminated, there remained strong relationships (.654 and .485, respectively,

$p < .0005$). This degree of relationship suggested that seriation itself accounted for approximately forty per cent of the variance in arithmetic scores and twenty-five per cent of the variance in reading scores. For this population sample, seriation appeared to have greater predictive value for achievement in arithmetic than in reading. This was contrary to the findings reported by Nelson, in which he explained equal predictive validity of the Seriation Test for achievement in both reading and arithmetic on the grounds that both of these are skills which involve logically structured symbol systems.[242]

The pattern of high intercorrelations obtained for seriation and perception, seriation and arithmetic, and perception and arithmetic are, however, fully in accord with Piaget's theory and expectations. This kind of interrelationship was confirmed in the experimental study reported by Elkind.[243] In contrast to the idea of reading and arithmetic based on similar or related skills, Piaget rests on the hypothesis that the internalization of grouping, ordering, and counting operations precede and specifically give rise to arithmetic operations. Elkind interprets and explains this in terms of a system of numerals assigned to elements which are both classed and ordered and "...the development of number can be viewed as an attempt to coordinate asymmetric (series) with symmetric (class) relations".[244] The results obtained in this

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[242] Nelson, op. cit., p. 77

[243] Cf. supra., p. 128.

[244] Elkind, op. cit., p. 292

study appeared to confirm this conceptualization of arithmetic ability. The discrepancy with Nelson's findings may be artifacts of the particular tests used or a function of the differences in the population sampled.

In the analysis of variance studies (Tables 24 and 28) arithmetic achievement was controlled as an independent variable in combination with class and ethnic group, with seriation as the dependent variable. In both instances, arithmetic was highly significant ($p < .001$), although neither ethnic group nor social class membership was demonstrated to have any significant effects on seriation independently or in interaction with arithmetic.

While it is noteworthy that for this population the correlation between seriation and reading is useful, albeit to a lesser degree than that for arithmetic, the negligible correlation between reading and intelligence ($r = .008$, not significant) suggested special conditions may exist in this population. There was, after all, a substantial correlation between intelligence and arithmetic ($r = .462$, $p < .005$). This discrepancy constitutes a phenomenon which is only partially explained by the fact that reading and arithmetic which have been typically reported as of a low order, but positively and significantly correlated in the normal school population,[245] do not have any apparent relationship with each other in this group ($r = .034$). In spite of the absence of any demonstrable relationship between reading and arithmetic, however, the Seriation Test was significantly related to both of these skill achievements.

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[245] Anastasi, op. cit., (Psychological Testing, pp. 348 et segq.)

SOCIO-CULTURAL FACTORS

The comparison of ethnic composition of students in the special classes with those in the general elementary school population in Stockton Unified School District (Table 1) suggested a disproportionately large number of Negro children were included and also (to a lesser degree) an excessive number of Mexican-Americans, along with relative under-placement of the cominant white majority pupils. This resulted in almost equal numbers of Caucasian and Mexican children and a greater number of Negro children in the special education program. It was clear from the use of the two factor rating scale for student socio-economic status that the ethnic groups did not have equal distribution of social class ratings. This distribution itself, over-representing the ethnic minorities and confirming the compounding of factors of socio-economic disadvantage in the ethnic minority groups in the classes for the educable mentally retarded, appeared to confirm Dunn's charges about the nature of the student population rejected by the educational mainstream.[246]

Among the analyses reported in this study, however, in which ethnic group and social class membership were controlled in an attempt to gain further understanding of the nature of the population identified as 'educable mentally retarded', there were very few clear cut differences substantiated by tests of statistical significance. The

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[246] Cf. supra, p. 13.

discussion which follows deals with the factors of ethnic group and socio-economic status separately although the issues are obviously compounded since all of the ethnic minority group children were also from families of unskilled workers and/or those supported by public funds and also living in poor or very poor housing. The studies dealing with differences in socio-economic status were limited, of necessity, to the Caucasian pupils.

Ethnic group membership was significant in differentiating between the white and minority pupils in the Chi-square comparison on the Visual Motor Integration Test ($p < .01$). Whereas the median score actually divided the age scores of children from the ethnic minority groups, over three-fourths of the white children scored below the median (Table 8). A similar comparison on ratings of Conception of Space confirmed these results (Table 14). There were clear indications that the pupils from the ethnic minority groups in this population were more advanced in terms of development of space conception than the white students. However, in the Chi-square comparison on the Hidden Figures Test, there was no such evidence of differentiation on the basis of ethnic group (Table 15). Further consideration of the specific tasks involved in these measures suggested that the apparent discrepancy in the findings might be associated with the fact that the motoric response, which was an essential part of both the Visual Motor Integration Test and Conception of Space measures, was lessened in importance on the Hidden Figures. A hypothesis based on differential motor skills and aptitudes to account for this discrepancy is in accord with the reports of many investigators on differences in learning style and superior motor ability in some of

the ethnic minorities and socially disadvantaged.[247]

The analysis of variance studies in which ethnic group membership was controlled as an independent variable, in combination with IQ, perceptual ability, arithmetic achievement, and age, showed no significant effects on seriating ability, either as assessed independently or in the interaction term derived with each of these other factors, also treated as independent variables (Tables 26, 27, 28, and 29). In each of these studies, however, the other variables did contribute significantly to variance in seriation test scores: IQ at $p < .01$, and perception, arithmetic achievement, and age, all at $p < .001$.

Although the rigorous nature of statistical tests of significance and the treatment of group results tends to minimize cases of clinical interest and may obliterate important features of the data, there are some (not statistically significant) indications of differences among these groups which merit notice. There was a consistency in the direction of differences in group mean scores (Tables 26, 27, 28, and 29) which may provide direction for further study and clarification of the issues which have been raised about placement of children from the ethnic minority groups in special education programs.

Observation of the cell frequencies and mean scores in each of the studies in which ethnic group was used as a control variable points out that the Negro and Mexican-American children who scored lower on IQ tests, had poorer perceptual ability, and scored lower on arithmetic

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[247] Cf. supra., pp. 56-66.

achievement, had mean Seriation Test scores from ten to twenty points above their white counterparts. (However, mean scores for all three ethnic groups in the higher IQ, better perceptual ability, and higher arithmetic achievement cells were quite closely comparable.) Most particularly, in the analysis of variance study by age and ethnic group, the mean scores for the younger children were:

1. Negroes - 71.90
2. Whites - 44.60
3. Mexicans - 80.5

There may be differences and variation in the development of cognitive structure which are neither tapped in the original placement procedures nor given any weight in educational programs. But the indicated differences between the younger white children and those of the ethnic minority groups who are placed in special education tends to give credence to the claims that socially disadvantaged children are shunted into these programs with less consideration of their abilities.

The limitation on the size of the samples in which socio-economic status could be controlled as an independent variable is itself a problem in the statistical treatment of this data. Differences between the lower and middle class groups on the Chi-square comparison on the Visual Motor Integration Test were not significant (Table 9). In the analysis of variance studies in which socio-economic status was paired with arithmetic achievement and IQ (Tables 24 and 25), there was no significant effects attributable either to socio-economic status or to socio-economic status in interaction with the variables with which it was paired. Again, however, there were large differences in the mean

scores reported in the cell distribution in these studies. The lower class children had higher mean scores on the Seriation Test than those from middle class homes. In spite of the very small sample, the t-test for differences between the means (Table 24) approached statistical significance, with p between .05 and .01.

These indications of differences favoring the lower socio-economic and ethnic minority groups are all the more remarkable since differences, if any, generally favor those who are more socially advantaged. Nelson concluded in regard to group differences in seriation:

> A reanalysis of the original ST validation data contradicted the finding that socio-economic level as a variable was not related to seriation ability. Middle class children do seem to seriate better than lower class children ($p. < .01$). White children may seriate better than Negro children, but the racial distinction was not significant in this study. The racial means departed from each other in the same direction as was indicated in the initial test report, however.[248]

The indication that the disadvantaged children in the regular school program are inferior in seriating ability to those who are more favorably socially endowed while there are suggestions of differences favoring the minority and lower class children in the special education program seems particularly anachronistic.

It is possible that the lower class white children and those from the ethnic minorities have varying patterns or constellations of abilities and differences in learning style than children raided in middle class homes. This data also offered some corroboration of the allegations that lower class children (regardless of color) are more

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[248] Nelson, op. cit., p. 79.

likely to be placed in the special education programs.[249] However, the corollary must also be considered: that the groups, as constituted on the basis of socio-cultural factors, actually are differentiated by varying etiological factors for the observed 'retardation', which may, in turn, give rise to differences in patterns of impairment.[250] It is possible that the development of seriation as a cognitive structure is hindered more severely in those whose retardation is on the basis of organic damage.

In the studies in which sex was used as an independent variable, in connection with IQ and perception, there were no significant effects on seriating ability related to the categorization by sex or the interaction terms (Tables 22 and 23). Again, however, references to the cell mean scores indicated small, but consistent, differences which favored the girls. This finding is in accord with data based on samples of children of elementary school ages, in which the preponderance of evidence favors the girls.[251] In the history of the intelligence testing movement, there are numerous reports of differences in intellectual function between the sexes, despite the efforts of test constructors to avoid items which differentiated between the sexes. The speculation about this phenomenon has been based on observation of earlier maturation in girls. Also, the hypothesis has been proposed that although the

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[249] Cf. supra., pp. 5 and 13.

[250] Cf. supra., pp. 42-45.

[251] Pintner, op. cit., pp. 496-503.

girls have a slight advantage in terms of group average, the boys show more variability and produce more geniuses.[252]

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[252] Ibid.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The data as presented in this report in the plethora of statistical studies may appear to be minutiae and trivia related to problems which are wholly internal to, and of limited concern in, the science of psychology. The apologia for such studies is perhaps best stated by Scott Greer:

> The crucial experiemnt is relatively rare in social inquiry. More common is the pilot inquiry, the descriptive study, the application of some theory to new data, the collection of new evidence for new hypotheses developed from older notions...Problems that seem wholly internal to a social science may, in the long run, be of most significance for both policy and philosophy; their solutions may revolutionize our general conceptions of the constraints and possibilities of human action.[253]

It is grandiose and pretentious to expect that any single study in this particularly complex area will offer total 'solutions'. However, it is hoped that this study may contribute in some measure towards such solutions. There are implications in the findings which have relevance for current problems of great significance in psychology and education.

IMPLICATIONS OF THE FINDINGS

The implications of the results presented and discussed in Chapters IV and V of this report are summarized in the following sections in terms of their relevance for (1) theoretical issues about the

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[253] S. Greer, The Logic of Social Inquiry, (Chicago: Aldine Publishing Co., 1969) pp. 13-14.

structure of intelligence and its development, (2) educational applications in assessment and programming, and (3) recommendations for further investigation.

Theoretical Issues

1. In general, the path of development appears to be the same for children identified as 'educable mentally retarded' as has been described for normal children. But there are clear indications of some unitary or coordinating pattern of ability which is even more significantly related to the variations in development and manifestation of perceptual and seriating ability than is maturation alone. The evidence for this intercorrelation of abilities is in accord with the postulation of a "common domain of individual variation...that justifies assigning a single label, such as 'intelligence', to this domain".[254]

In the presence of anomalies in intellectual functioning sufficiently gross to produce isolation from the normal school program, there is markedly delayed development in both perceptual and seriating ability.

2. Any measure of perceptual competence requires some performance on the part of the subject which is mediated (to varying degrees) by factors assessed in most commonly accepted intelligence tests. The tasks used for estimating perceptual adequacy required attention to the significant features and comprehension of the nature of the problem presented.

The mutual interdependence between perception and intelligence,

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[254] Cf. supra., p. 26.

contrary to the rigorous differentiation maintained by Piaget between these 'modes of adaptation', was demonstrated in Chi-square studies on the Conception of Space. Age as a variable was not significant in relation to the stage of development; IQ, on the other hand, was clearly associated with development of space conception ($p < .01$).

3. The overshelming consistency with which seriation emerged as more closely related to perceptual ability than it was to IQ is a significant finding which offers partial affirmation of Piaget's theory concerning the perceptual roots of seriation. The fact that correlation coefficients for seriation and academic achievement are higher than those produced by IQ and academic achievement indicate that the conceptualization of seriation as a structure in the development of logical thinking reflects empirically verifiable changes in the mental life of the growing child. Seriation, as indicated in Nelson's conclusions in his study, may be the construct which enables bridging the gap between perceptual ability and reasoning.[255]

Educational Applications

1. The need for broadening the base on which ability is assessed is implied by the fact that, in spite of the predictive value of intelligence tests for estimates of perceptual adequacy and seriating ability, seriation offers additional advantages in relation to prediction of academic achievement. Rather than rejection of intelligence tests in response to the demonstrated inadequacies in the presently used instruments, a more appropriate and productive solution

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[255] Cf. supra., p. 48

appears to lie in the extension of such testing. Individual assessment with tests evaluating the development of reasoning in a process oriented evaluation should move closer to the educational demands for effective prescriptive testing.

2. If intellectual function is analyzed in the course of ability testing so that the mode and level of reasoning is assessed, it should be possible to achieve integration between testing and training procedures in an effort to stimulate greater mental growth.

The results obtained on this population suggest that the close relationship among seriation, arithmetic, and perception and the higher correlation with academic achievement for seriation than for intelligence may be related to the underlying process of reasoning. The development of more 'logical' reading programs may facilitate acquisition of reading skills at the lower levels. Some of the current efforts in this direction (i.e., International Teaching Alphabet and Color-coded Reading programs) appear to be well founded and should be implemented in the special education classes in an effort to bring reading skills to the level of potentiality indicated by arithmetic achievement and by more compreshensive assessment procedures.

3. The suggestion of differences favoring the ethnic minority and lower socio-economic groups in seriating ability in the special education program indicates that it might be worthwhile to explore the possibilities for applying rememdiation procedures for these pupils. Training in seriation and intensive 'logical' language development programs (such as those currently under consideration by Chomsky, et. al.) should be implemented to see what changes, if any, can be

produced.

In an applied research design, it would be worthwhile, as well, to follow through on such an intensive training program to determine what patterns of correlation among these various dimensions are found to exist after training.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

1. The apparent existence of a unitary factor underlying the intercorrelation of abilities, which seems to be best described as 'reasoning', is a concept in accord with Piaget's theoretical construction of 'logical thinking'. Further confirmation of this might be obtained by testing this population with measures designed to elicit responses in terms of Guilford's structure of intelligence model. A factor analytic approach to such data and measures of seriation might ascertain whether clusters related to 'reasoning' are, in fact, produced.

2. Nelson's study was reported on a population of lower socio-economic status; this study was limited to the population in special education. It is recommended that further efforts be directed to a more complete exploration, across the full gamut of socio-economic levels and the total range of intellectual functioning, in order to verify the generalizability and the implications of the findings reported.

3. There is a need for further exploration of the lack of relationship between intelligence and reading and between reading and arithmetic in this population. This finding may be an artifact of the

reading test used or limited to special education students in this particular school district for some reason. It is discrepant from the voluminous studies reported on normal school populations and merits further explanation.

4. There is also a need for further exploration of the differences in ethnic group mean scores on the Seriation Test. Similar collection of data from students in other school districts, which may have different placement criteria for special education, and/or studies on populations in other parts of the country would be helpful in clarifying the definition of students from the ethnic minorities and lower socio-economic levels who are placed in special programs.

5. Further exploration of the possibility of differences between the sexes in seriating ability (and on other variables) is also warranted. While the differences in group mean scores on the Seriation Test as reported in this study are not statistically significant, they are impressively consistent. This may be a function of unknown selection factors in this particular sample or an expression of differences in maturational rate which are manifested in a delayed form among the retarded. However, the differences do raise questions about the possibility that intelligence tests, which have eliminated items which differentiated between the sexes, may have reduced their effectiveness and obscured information about basic concepts related to mental growth.

6. Finally, the clear evidence throughout these studies that this group of limited students, identified as 'educable mentally retarded' can be differentiated on the basis of functioning levels of perception and intelligence adds weight to the research evidence

claiming diagnostic implications for test performance. A more clinically oriented study, sampling cases in terms of diagnosed organic etiology, compared with 'undifferentiated' retardates, is indicated to obtain more information relevant to differences in the etiology of mental retardation.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Ames, L. B., et al. Child Rorschach Responses; Developmental Trends from Two to Ten Years. New York: Paul B. Hoeber, 1952.

Anastasi, A. Differential Psychology. Third edition. New York: The MacMillan Company, 1958.

_____. Psychological Testing. New York: The MacMillan Company, 1954.

_____. "Standardized Ability Testing" in Handbook of Research Methods in Child Psychology, P. H. Mussen, editor. New York: John Wiley and Sons, 1960.

Beery, K. E. Developmental Test of Visual-Motor Integration: Administration and Scoring Manual. Chicago: Follett Publishing Company, 1967.

Bereiter, C. and S. Engelmann. Teaching Disadvantaged Children in the Preschool. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966.

Boring, E. G. Sensation and Perception in the History of Experimental Psychology. New York: D. Appleton-Century Company, 1942.

Bruner, J. S. "The Cognitive Consequences of Early Deprivation" in Sensory Deprivation, P. Solomon, et al, editors. Cambridge, Mass: Harvard University Press, 1961.

Dearborn, W. "The Development of the Intellect" in The Child: His Nature and His Needs, M. W. O'Shea, editor. Valparaiso, Indiana: The Children's Foundation, 1924.

Deutsch, C. "Environment and Perception" in Social Class, Race, and Psychological Development, M. Deutsch, I. Katz, and A. R. Jensen, editors. New York: Holt, Rinehart and Winston, 1968.

Deutsch, M., et al. The Disadvantaged Child. New York: Basic Books, Inc., 1967.

Dolphin, J. E. and W. M. Cruikshank. "The Figure-Background Relationship in Children with Cerebral Palsy" in Readings on the Exceptional Child, E. P. Trapp and P. Himmelstein, editors. New York: Appleton-Century-Crofts, Inc., 1962.

Edwards, A. L. Experimental Design in Psychological Research. Third edition. New York: Holt, Rinehart and Winston, Inc., 1968.

Eels, K., et al. Intelligence and Cultural Differences. Chicago: University of Chicago Press, 1951.

Ellis, N. R., editor, Handbook of Mental Deficiency. New York: McGraw Hill Book Company, 1963.

Ferguson, G. A. Statistical Analysis in Psychology and Education. New York: McGraw Hill Book Company, 1959.

Flavell, J. H. The Developmental Psychology of Jean Piaget. Princeton, New Jersey: D. Van Nostrand Company, 1963.

Gallagher, J. W. "Production Thinking" in Review of Child Development Research, Vol. 1, M. L. Hoffman and L. W. Hoffman, editors. New York: Russell Sage Foundation, 1964.

Garrett, H. E. Statistics in Psychology and Education. Fifth edition. New York: David McKay Company, 1958.

Gibson, E. J. "Perceptual Development" in Child Psychology: 62nd NSSE Yearbook, Part I, H. S. Stevenson, editor. Chicago: University of Chicago Press, 1963.

Goodenough, F. "The Measurement of Mental Growth in Young Children" in Manual of Child Psychology, Second edition, L. Carmichael, editor. New York: John Wiley and Sons, 1954.

Gottsman, I. I. "Biogenetics of Race and Class" in Social Class, Race, and Psychological Development, M. Deutsch, I. Katz and A. R. Jensen, editors. New York: Holt, Rinehart and Winston, 1968.

Greer, S. The Logic of Social Inquiry. Chicago: Aldine Publishing Company, 1969.

Guilford, J. P. The Nature of Intelligence. New York: McGraw Hill Book Company, 1967.

Heider, F. "On Perception, Event Structure and the Psychological Environment" in Psychological Issues, G. S. Klein, editor. New York: International Universities Press, 1959.

Helmstadter, G. C. Principles of Psychological Measurement. New York: Appleton-Century-Crofts, 1964.

Hunt, J. McV. Intelligence and Experience. New York: The Ronald Press, 1961.

Inhelder, B. and J. Piaget. The Early Growth of Logic in the Child: Classification and Seriation. London: Routledge and Kegan Paul, 1964.

Jensen, A. R. "Basic Processes in Intellectual Development" in Social Class, Race, and Psychological Development. M. Deutsch, I. Katz, and A. R. Jensen, editors. New York: Holt, Rinehart and Winston, 1968.

Jones, H. E. "The Environment and Mental Development" in Manual of Child Psychology, Second edition, L. Carmichael, editor. New York: John Wiley and Sons, 1954.

Kephart, N. C. The Slow Learner in the Classroom. Columbus, Ohio: Charles E. Merrill Books, Inc., 1960.

Kerlinger, F. N. Foundations of Behavioral Research. New York: Holt, Rinehart and Winston, Inc., 1965.

Kerner, O. (Chairman). Report of the National Advisory Commission on Civil Disorders. New York: Bantam Books, 1968.

Kidd, A. H. and J. L. Rivoire, editors. Perceptual Development in Children. New York: International Universities Press, 1966.

Kirk, S. A. Public School Provision for Severely Retarded Children. Albany, New York: Inter-departmental Health Resources Board, 1957.

Klineberg, O. Race and Psychology. Paris: UNESCO, 1951.

_____. Race Differences. New York: Harper, 1935.

Koppitz, E. M. The Bender Gestalt Test for Young Children. New York: Grune and Stratton, 1964.

Learning Readiness System Seriation Test. New York: Harper and Row, Inc., 1968.

O'Connor, N. "The Prevalence of Mental Defect" in Mental Deficiency: The Changing Outlook, A.M. Clarke and D. B. Clarke, editors. Glencoe, Illinois: The Free Press, 1958.

Pasamanick, B. and H. Knobloch. "Epidemiological Studies on the Complications of Pregnancy and the Birth Process" in Prevention of Mental Disorders in Children, G. Caplan, editor. New York: Basic Books, Inc., 1961.

Penrose, L. S. The Biology of Mental Defect. Revised edition. London: Sidgwick and Jackson, 1954.

Piaget, J. The Child's Conception of Number. New York: Humanities, 1952.

_____. The Language and Thought of the Child. New York: Harcourt, Brace, 1926.

_____. The Origins of Intelligence in Children. New York: International Universities Press, 1952.

_____. Six Psychological Studies. New York: Random House, 1967.

_____ and B. Inhelder. The Child's Conception of Space. London: Routledge and Kegan Paul, 1956.

Pintner, R. P. Intelligence Testing: Methods and Results. New York: Henry Holt and Company, 1932.

Reissman, F., editor. The Culturally Disadvantaged Child. New York: Harper and Row, 1962.

Rothstein, J. H., editor. Mental Retardation. New York: Holt, Rinehart and Winston, 1963.

Sarason, I. G. Personality: An Objective Approach. New York: John Wiley and Sons, 1966.

Sarason, S. B. and T. Gladwin. Psychological Problems in Mental Deficiency. Third edition. New York: Harper and Row, 1959.

Sigel, I. E. "The Attainment of Concepts" in Review of Child Development Research, Vol. 1, M. L. Hoffman and L. W. Hoffman, editors. New York: Russell Sage Foundation, 1964.

Spearman, C. The Abilities of Man. New York: MacMillan Company, 1927.

Spivack, G. "Perceptual Processes" in Handbook of Mental Deficiency, N. R. Ellis, editor. New York: McGraw Hill Book Company, 1963.

Stanford-Binet, Form L.M. New York: Houghton Mifflin Company, 1960.

Strauss, A. A. and L. E. Lehtinen. Psychopathology and Education of the Brain Injured Child. New York: Grune and Stratton, 1947.

Terman, L. M. and M. A. Merrill. Stanford-Binet Intelligence Scale, Manual for Third Revision, Form L-M. Boston: Houghton Mifflin Company, 1960.

The Random House Dictionary of the English Language. New York: Random House, 1966.

Thurstone, L. L. A Factorial Study of Perception. Chicago: University of Chicago Press, 1944.

Tuddenham, R. D. "The Nature and Measurement of Intelligence" in Psychology in the Making, L. Postman, editor. New York: Alfred A. Knopf, 1962.

Tyler, L. The Psychology of Human Differences. New York: Appleton-Century-Crofts, 1965.

Vernon, M. D. "Perception in Relation to Cognition" in Perceptual Development in Children, A. H. Kidd and J. L. Rivoire, editors. International Universities Press, 1966.

Vernon, P. E. The Structure of Human Abilities. New York: John Wiley and Sons, 1950.

Wallach, M. S. "Research on Children's Thinking" in Child Psychology: 62nd Yearbook of the National Society for the Study of Education, H. S. Stevenson, editor. Chicago: University of Chicago Press, 1962.

Wallach, M. A. and N. Kogan. Modes of Thinking in Young Children. New York: Holt, Rinehart and Winston, 1965.

Warner, W. L., et al. Social Class in America. Chicago: Science Research Associates, 1949.

Wechsler, D. The Measurement and Appraisal of Adult Intelligence. Fourth edition. Baltimore: Williams and Wilkins, 1958.

Wechsler Intelligence Scale for Children. New York: Psychological Corporation, 1949.

Werner, H. Comparative Psychology of Mental Development. Revised edition. New York: International Universities Press, Inc., 1957.

Whiteman, M. and M. Deutsch. "Social Disadvantage as Related to Intellective and Language Development" in Social Class, Race, and Psychological Development, M. Deutsch, I. Katz and A. R. Jensen, editors. New York: Holt, Rinehart and Winston, 1968.

Wide Range Achievement Test. Wilmington, Delaware: Guidance Associates, 1965.

B. PERIODICALS

Anastasi, A. "Psychology, Psychologists, and Psychological Testing", American Psychologist, 22:297, 1967

Bayley, N. "On the Growth of Intelligence", American Psychologist, 10:807, 1955.

Bender, L. A Visual Motor Gestalt Test and its Clinical Use, Research Monograph No. 3. New York: American Orthopsychiatric Association, 1938.

Bruner, J. S. "Inhelder and Piaget's The Growth of Logical Thinking: I, A Psychologist's Viewpoint", British Journal of Psychology, 50:363-370, 1959.

_____. "On Perceptual Readiness", Psychological Review, 64:123-152, 1957.

Burt, C. "The Structure of the Mind: A Review of the Results of Factor Analysis", British Journal of Educational Psychology, 19:100-111, 176-199, 1949.

Cattell, R. B. "Theory of Fluid and Crystallized Intelligence", Journal of Educational Psychology, 54:1-22, 1963.

Cooper, R. and J. Zubek. "Effects of Enriched and Restricted Early Environments on the Learning Ability of Bright and Dull Rats", Canadian Journal of Psychology, 12:159-164.

Covington, M. V. "Stimulus Discrimination as a Function of Social Class Membership", Child Development, 38:607-613, 1967.

Dunn, L. M. "Special Education for the Retarded: Is Much of It Justifiable"? Exceptional Children, 35:5-24, 1968.

Elkind, D., et al. "Effects of Perceptual Training on Unmatched Samples of Brain Injured and Familial Retarded Children", Journal of Abnormal Psychology, 70:107-110, 1965.

_____. "Modified Word Recognition, Reading Achievement, and Perceptual De-Centration", Journal of Genetic Psychology, 107:235-251, 1965.

_____. "Discrimination, Seriation, and Numeration of Size and Dimensional Differences in Young Children", The Journal of Genetic Psychology, 104:275-296, 1964.

Fantz, R. L. "The Origin of Form Perception", Scientific American, 204:66-72, 1961.

Fishman, J. A., et al. "Guidelines for Testing Minority Group Children", Monograph Supplement, Journal of Social Issues, 20:127-145, No. 2, 1964.

Fitzhugh, L. D., et al. "Sensori-motor Deficits of Brain Damaged Subjects in Relation to Intelligence Level", Perceptual and Motor Skills, 15:603-608, 1962.

Frazeur, H. A. and Z. P. Hoakley. "Significance of Psychological Test Results of Exogenous and Endogenous Children", American Journal of Mental Deficiency, 51:384-388, 1947.

Freedman, D. "Constitutional and Environmental Interactions in Rearing of Four Breeds of Dogs", Science, 127:585-586, 1958.

Goodnow, J. J. and G. Bethon. "Piaget's Tasks: Effects of Schooling and Intelligence", Child Development, 37:573-582, 1966.

Graham, V., et al. "Generalization of the Concept of Middleness", Journal of Genetic Psychology, 65: 227-237, 1944.

Guilford, J. P. "The Structure of Intellect", Psychological Bulletin, 53:267-293, 1956.

Hebb, D. O. "The Motivating Effects of Exteroceptive Stimulation", American Psychologist, 13:109-115, 1958.

Heber, R., editor. "A Manual on Terminology and Classification in Mental Retardation", Monograph Supplement, American Journal of Mental Deficiency, 64, No. 2, 1958.

Hermelin, B. and R. O'Connor. "Recognition of Shapes by Normal and Subnormal Children", British Journal of Psychology, 52:281-284, 1961.

Herskovits, M. J. "On the Relation Between Negro-White Mixture and Standing in Intelligence Tests", Journal of Genetic Psychology, 33:30-42, 1926.

Hoakley, Z. P. and H. A. Frazeur. "Significance of Psychological Test Results of Endogenous and Exogenous Children", American Journal of Mental Deficiency, 50:263-271, 1945.

Hofstaetter, P. R. "The Changing Composition of 'Intelligence'; A Study of t-Technique", Journal of Genetic Psychology, 85:159-184, 1954.

Hood, H. B. "An Experimental Study of Piaget's Theories of the Development of Number", British Journal of Psychology, 53:273-286, 1962.

Klineberg, O. "Negro-White Differences in Intelligence Test Performance", American Psychologist, 18:198-203, 1963.

Krech, D., et al. "Relations Between Brain Chemistry and Problem Solving Among Rats Raised in Enriched and Impoverished Environments", Journal of Comparative and Physiological Psychology, 55:801-807, 1962.

Levine, R., et al. "The Relation of the Intensity of a Need to the Amount of Perceptual Distortion", Journal of Psychology, 13:283-293, 1942.

Maslow, P., et al. "The Marianne Frostig Developmental Test of Visual Perception", Perceptual and Motor Skills, 19:463-499, 1964.

McNemar, Q. "Lost: Our Intelligence? Why?", American Psychologist, 19:871-883, 1964.

O'Neill, W. M. "Basic Issues in Perceptual Theory", Psychological Review, 65:348-359, 1958.

Peel, E. A. "An Experimental Examination of Some of Piaget's Schemata Concerning Children's Perception and Thinking and a Discussion of Their Educational Significance", British Journal of Educational Psychology, 29:89-103, 1959.

Riesen, A. H. "Arrested Vision", Scientific American, 183:16-19, 1950.

Rose, D., et al. "Some Problems in Perceptual Handicap of Mentally Retarded Children", Journal of Genetic Psychology, 104:123-133, 1964.

Rosenzweig, M. R. "Environmental Complexity, Cerebral Change, and Behavior", American Psychologist, 21:321-332, 1966.

_____, et al. "Variation in Environmental Complexity and Brain Measures", Journal of Comparative and Physiological Psychology, 55:1092-1095, 1962.

Scott, R. "Head Start Before Home Start", Merrill Palmer Quarterly, 13:317-321, 1967.

Stevenson, H. W. and I. Iscoe. "Overtraining and Transposition in Children", Journal of Experimental Psychology, 47:251-255, 1954.

Welch, L. and L. Long. "The Higher Structural Phases of Concept Formation of Children", Journal of Psychology, 9:59-95, 1940.

Werner, H. "Functional Analysis in Mentally Deficient Children", American Journal of Abnormal and Social Psychology, 34:37-62, 1939.

Wheeler, L. R. "A Comparative Study of the Intelligence of East Tennessee Mountain Children", Journal of Educational Psychology, 33:321-334, 1942.

White, B. L., et al. "Observations on the Development of Visually Directed Reaching", Child Development, 35:349-364, 1964.

Witty, P. A. and M. D. Jenkins. "Intra-race Testing and Negro Intelligence", Journal of Psychology, 1:174-192, 1936.

Wohlwill, J. J. "From Perception to Inference" in Monograph of Society for Research in Child Development, W. Kennan and C. Kuhlman, editors. New York: 1962.

Woodward, M. "The Behavior of Idiots Interpreted by Piaget's Theory of Sensori-Motor Development", Journal of British Educational Psychology, 29:60-71, 1959.

Zigler, E. and J. de Labry. "Concept Switching in Middle Class, Lower Class and Retarded Children", Journal of Abnormal and Social Psychology, 65:267-273, 1962.

Zuckerman, C. B. and I. A. Rock. "A Reappraisal of the Roles of Past Experience and Innate Organizing Processes in Visual Perception", Psychological Bulletin, 54:269-296, 1957.

C. UNPUBLISHED MATERIAL

Jensen, A. R. "Patterns of Mental Ability and Socio-economic Status". Paper presented at the Annual Meeting of the National Academy of Sciences, Washington, D. C., April 24, 1968.

McFarland, F. "The Diagnostic Significance of Fable Completion by Children". Unpublished Master's Thesis, Stanford University, 1949.

Nelson, J. W. "Construct Validation of the Learning Readiness System-Seriation Test". Unpublished Doctoral Dissertation, Indiana University, 1968.

Rapier, J. "The Learning Abilities of Normal and Retarded Children as a Function of Social Class". Unpublished Doctoral Dissertation, University of California, Berkeley, 1966.

Sitkei, E. G. "Comparative Structure of Intellect in Middle and Lower Class Four Year Old Children of Two Ethnic Groups". Doctoral Dissertation, University of Southern California, 1966, Dissertation Abstracts, 1967.

D. PUBLICATIONS OF THE GOVERNMENT

Education Code, Vol. 1, State of California, Department of General Services Documents Section, Sacramento: 1968

U. S. Bureau of the Census. U. S. Censuses of Population and Housing: 1960. Census Tracts. Final Report PHC(1)-153. U. S. Government Printing Office, Washington, D. C., 1962.

APPENDICES

APPENDIX A

Teacher Evaluation of Student Socio-economic Status

TEACHER EVALUATION OF STUDENT SOCIO-ECONOMIC STATUS

Student's name _____

Birthdate _____ Sex _____ School _____

Teacher's name _____

On the basis of your knowledge of your students from observations, home visits, etc., please check the item in each of the following categories which you think best applies to the family.

1. OCCUPATION

__ PROFESSIONALS AND LARGE BUSINESS OWNERS. Lawyer, doctor, CPA, owner of business valued at $40,000 or above, school superintendent, etc.

__ SEMI-PROFESSIONAL AND OFFICIALS OF LARGE BUSINESSES. Nurses, teachers, librarian.

__ CLERKS AND KINDRED WORKERS. Social workers, accountants, salesworkers, etc.

__ PROPRIETORS OF SMALL BUSINESSES. Valued at less than $40,000, plumbers, barbers, radio repairmen, shoe repair shop, etc.

__ SEMI-SKILLED WORKERS. Truck driver, carpenter's assistant, waitress, etc.

__ UNSKILLED WORKERS. Heavy labor, odd jobs, janitor, migrant worker, etc.

2. HOUSE TYPE

__ EXCELLENT HOUSES. Large, single-family, good repair, large yards, good lawns.

__ VERY GOOD HOUSES. Slightly smaller than excellent houses, but considerably larger than basic utility demands, etc.

__ GOOD HOUSES. Only slightly larger than basic utility, good repair.

__ AVERAGE HOUSES. Average in size, state of repair, lawns, yards.

__ FAIR HOUSES. Large houses in less than average condition, small house in good condition.

__ POOR HOUSES. Badly run-down condition, poor lawns and yards.

__ VERY POOR HOUSES. Deteriorated beyond repair, unsafe for occupancy.

APPENDIX B

Hidden Figures Test

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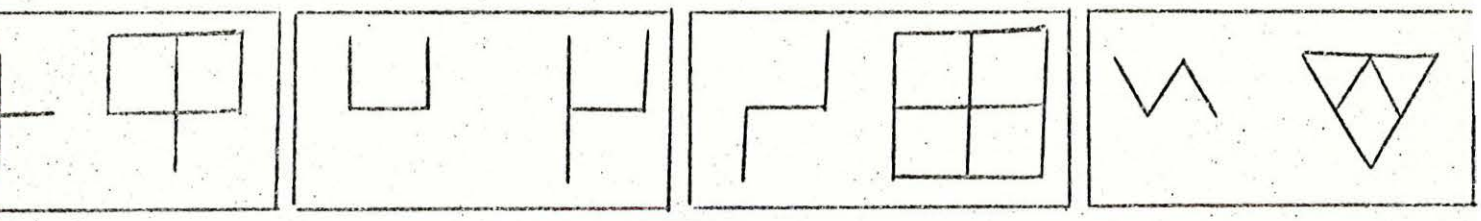

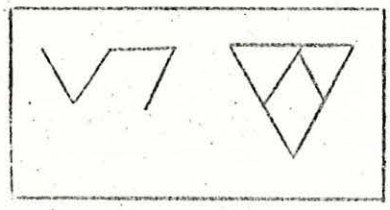

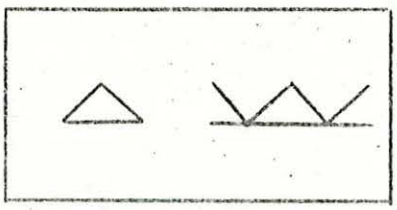

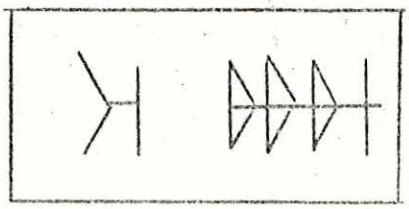

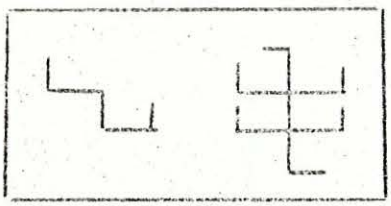

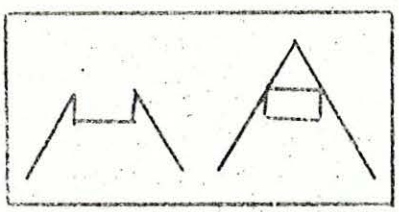

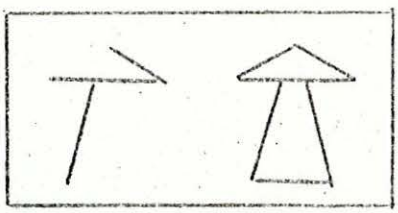

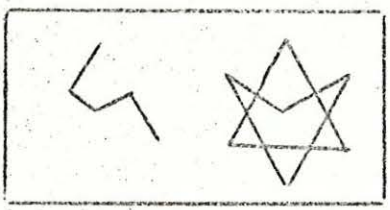

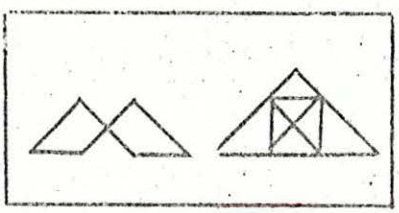

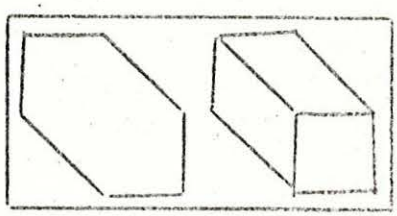

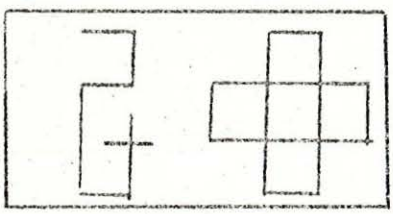

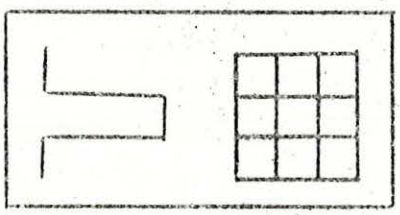

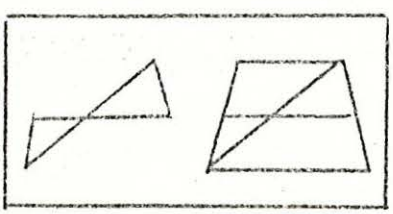

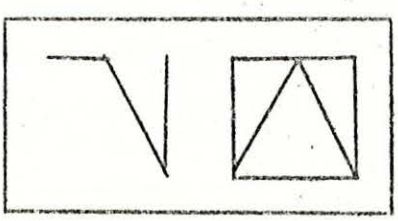

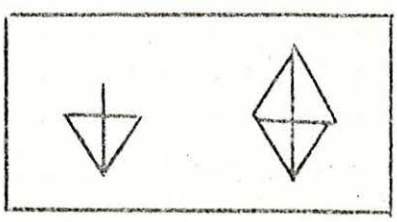

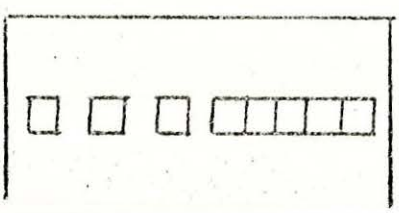

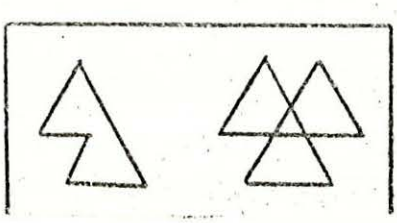

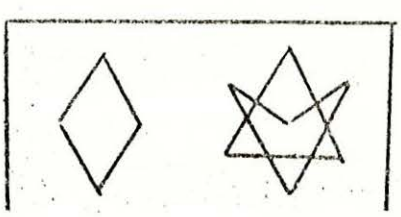

APPENDIX C

Copying Designs Test